INTERSTATE HIGHWAY 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

A Report to

The Montana Highway Commission

October 1960

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MEISSNER ENGINEERS, INC.

MONTANA HIGHWAY COMMISSION
RECEIVED
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HELENA, MONTANA

ROUTE TO

2 Interstate

MEISSNER ENGINEERS INC. · 300 WEST WASHINGTON · CHICAGO 6, ILLINOIS

January 9, 1961

Mr. Fred Quinnell, Jr.
State Highway Engineer
State Highway Department of Montana
Helena, Montana

Attention: Mr. Grover O. Powers,
Interstate Engineer

SUBJECT: Projects I-90-4(3)226 and
I-90-5(1)231
Our Reference No. 472

Dear Sir:

This will acknowledge receipt of your letter of December 21, and the Bureau Memo of December 14, concerning the Butte-Whitehall project. We appreciate your kindness in letting us know about the favorable comments you have heard regarding the report and will attempt, in this letter, to answer the questions that have been raised about certain decisions contained in our report.

Independent Roadways

The concept of individually aligned roadways in highway design is becoming increasingly important from the standpoint of appearance and cost savings. It is possible to provide such design over certain portions of this route. We have added Page 48 to the text of our report wherein we discussed this subject as it applies to the Butte-Whitehall project.

The primary purpose of our report was to perform a reconnaissance study to determine the most feasible routing of the Interstate highway between Butte and Whitehall, Montana. This required the study of a good many lines, all of which were designed on the same basis and to comparable standards. We feel that a study of independent roadways for the line that is finally selected for construction can and should be made, and that this study should be undertaken during the preliminary design phase of the project.

Exposure

In setting all alignments, we have taken into consideration the problems associated with winter maintenance and have attempted to place the roadways so that they would have a southern exposure wherever possible. The terrain north of Homestake Creek, where a southern exposure down the east slope of the Continental Divide seems feasible, is of such a character that the cost of a freeway placed there would be prohibitive.

Sustained Heavy Grades

We share the concern that has been expressed over the sustained 7% grades that are required in Line 1A, the recommended alignment. This concern is reasonable since steep grades usually increase road user costs considerably. That is not the case in this instance.

As you know, the 3 most feasible alignments over Homestake Pass have maximum grades of 7% (Line 1A), 6% (Line 1C) and 5% (Line 1B). We have expanded Tables 6 and 11 of the report to include road user costs for all three of these lines. Table 6 shows that the total length of grade in the 3 to 7% range is 7.4 miles for Lines 1A and 1C. This compares to a length of 8.8 miles of 3 to 5% grade for Line 1B. This additional length of heavy grade on Line 1B increases the road user costs above that of Line 1A and 1C. Another factor which favors Line 1A is the length of sustained grade. The maximum length of steep sustained grade on Line 1A consists of 1.7 miles of 7% and 1.8 miles of 6% grade, for a total of 3.5 miles. This can be compared to the 5.2 miles of sustained 5% grade on Line 1B and 3.8 miles of sustained 6% grade on Line 1C.

The operating characteristics of passenger vehicles will be essentially the same for all alternates with only a slight increase in fuel costs for Line 1A. A study of the operation of trucks on these grades was made using Highway Research Board Bulletin No. 104 entitled "Vehicle Climbing Lanes". These graphs show that the terminal speeds for heavy trucks on 5%, 6% and 7% grades are 9 MPH, 8 MPH and 7.5 MPH, respectively. These speeds were determined by actual tests using a typical heavy truck with a load of approximately 57,000 pounds. Our analysis shows that it will take a truck approximately 15 minutes to travel the entire sustained grade from the west for each alternate. The time for a truck to travel the entire sustained grade from the east is approximately 30 minutes for Line 1A, 33 minutes for Line 1B and 31 minutes for Line 1C.

Line 1A has the least initial expense by approximately \$3,000,000 and the economic analysis shown in Table 6 indicates that it will save the road user approximately \$15,000 annually. In addition, the benefit cost ratios, shown in Table 11, are 2.83 for Line 1A. 2.38 for Line 1B and 2.42 for Line 1C. These anlyses all support the choice of Line 1A with a 7% grade as the recommended alignment over Homestake Pass.

Interstate criteria as set forth by the Bureau of Public Roads permits a maximum grade of 7% in mountainous terrain. Any crossing of the Continental Divide in the area under consideration will require sustained heavy grades, or greatly increased construction and road user costs. With this in mind and with the engineering data that has been developed, we have no choice but to recommend that Line 1A is the least expensive of all lines studied and that it presents the greatest benefit to the road user. A reduction in the maximum allowable grade would have to be a policy decision, which is not within our power to make.

Any discussion of grades for this project should include a discussion of traffic volumes. Interstate 90 between Butte and Whitehall will be among the most lightly traveled interstate routes in the nation. The ADT in 1975 will be less than 4,000 vehicles in both directions. Such volumes should certainly be considered in future decisions on this subject.

Road User Costs

To further emphasize the benefits to the road user, we will include with this letter three (3) sets of additional road user cost computations based on the maximum traffic at the year 1975. This would also be the average year over the life of the road if we consider that the highway will be completed by 1965 and assume a 20 year life for the road.

You will note that the saving to the road user for Line 1A is $85,000 over Line 1B and $18,000 over Line 1C. All benefit costs now show a ratio of more than 3, with Line 1A still having the highest benefit cost ratio, nearly 4. This result is sensible when you consider that the basic reason Line 1A is the most desirable alignment is that the length of heavy grade is the shortest for this alternate.

We are sending under separate cover 30 revised copies of this report. Changes and/or additions have been made to Pages 21 and 48 of the text and Tables 6 and 11. We would appreciate it if you would return 30 copies of the report mailed to you last October. Enclosed you will find 20 copies each of the 4 revised pages, which will give you a total of 50 revised copies of the report.

Mr. Fred Quinnell, Jr.
Helena, Montana

Page Four
January 9, 1961

Also enclosed is a list of all of the work sheets that have been filed separately with your Department. Harlan Blindauer will discuss with you the disposition of other material still in our possession.

If there is anything further that we can do on this matter, please contact us. We are prepared to discuss at length any aspect of this job and to present whatever information we can to assist you.

Very truly yours,

MEISSNER ENGINEERS, INC.

Donald A. Walsh
Chief Civil Engineer

C.W. Tarman

By: C. William Tarman
Chief Highway Engineer

CWT:sk
Enclosures
CC :HBlindauer
BC :PHClayton
DDeVore

<u>MATERIAL SUBMITTED TO MONTANA HIGHWAY</u>

<u>DEPARTMENT</u>

<u>Prints (Two Sets)</u>

Plans - All study lines @ 1" = 200' and 1" = 400'
Interchange layouts @ 1" = 200'

Profiles - All study lines @ Horizontal 1" = 400', Vertical 1" = 40'
Crossroads @ Horizontal 1" = 200', Vertical 1" = 20'
Ramps @ Horizontal 1" = 200', Vertical 1" = 20'

Mass Diagrams - All Study Lines

Cost Estimates - All Study Lines

<u>Originals</u>

Profiles - Lines 1-B and ~~1-C~~ 1-C @ Horizontal 1" = 400', Vertical 1" = 40'

DONALD G. NUTTER, GOVERNOR
STATE OF MONTANA

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FRED QUINNELL, JR.
STATE HIGHWAY ENGINEER

HIGHWAY COMMISSION

STATE HIGHWAY DEPARTMENT
HELENA, MONTANA

IN REPLY REFER TO:

For Fred Q -

January 20, 1961

IN:GOP

Bureau of Public Roads
Capitol P. O. Box 277
Helena, Montana

Re: Interstate Projects
I 90-4(3)226 & I-IG 90-5(1)231
Butte - Whitehall Routing.

Gentlemen:

We acknowledge receipt of your letters, dated December 14, 1960 and January 3, 1961, furnishing various considerations and comments regarding the study and report that is being developed under contract by Meissner Engineers, Inc. in connection with the subject matter.

Since the essential and primary objective of this contracted work is to make a determination of the most feasible routing between Butte and Whitehall so that final and authoritive decisions will be established and thereby permit the program for the subject projects to advance to the location survey and design plans phase, we hereby attempt to cover only those items that, according to our best knowledge and judgment, are pertinent to this objective.

The letter of Meissners, dated January 9, 1961, and the indicated supplements and revisions to the report seem to cover the matters of concern referenced to date. In addition to this letter, we furnish herewith 3 complete copies of the revised report along with 3 copies of the revised pages and added tables necessary to correcting the copies of the report previously submitted. Also furnished are 3 sets of the profiles used in establishing the estimates and computations for line 1 B (5% grades) and line 1 C (6% grades).

In consideration of this report as it applies to the terms of the contract, it is our view that final acceptance and authorization for final payment is justified. We therefore respectfully request your recommendation in this regard.

(more)

Basically, the route established as being the most feasible by this study and report is the same as the route that was established as an approved route in connection with the 108(d) Study. We therefore believe the proper course of action is to proceed with the further required development of this established route on the basis of the Meissner study and recommendations to the extent that they are acceptable to the determinations and decisions applicable to the design phases of the program. We would appreciate your early authorization in this connection so that we can keep our program moving ahead.

Very truly yours,

FRED QUINNELL, JR.
State Highway Engineer

Grover O. Powers

By Grover O. Powers
Interstate Engineer

GOP:gh
Enclosures
cc: DeVore
Buswell

INTERSTATE HIGHWAY 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

A Report To

The Montana Highway Commission

By

Meissner Engineers, Inc.

Chicago, Illinois

October, 1960

MEISSNER ENGINEERS INC. · 300 WEST WASHINGTON · CHICAGO 6, ILLINOIS

October 10, 1960

Montana Highway Commission
Helena,
Montana

Gentlemen:

Pursuant to our agreement of February 15, 1960, we are pleased to submit herewith our engineering report for the Route Location Study of Federal Aid Interstate 90 from Butte to Whitehall, Montana. The accompanying report contains our conclusions in regard to the best routing through the study area along with sufficient text, tables, and exhibits to support our findings.

Alignment studies for many routes between Butte and Whitehall were made on contour maps supplied by the Montana Highway Department. These work sheets along with all profiles, cross-sections, and other details have been filed separately with your department.

We wish to thank the members of the Montana Highway Department for the invaluable assistance and cooperation given to us throughout the course of this study.

Sincerely yours,

MEISSNER ENGINEERS, INC.

Robert C. Meissner
President

CONSULTING ENGINEERS · DESIGNERS · CONSTRUCTORS · TELEPHONE FI 6-7171 · TELETYPE CG 2058 · CABLE MEISING

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INTRODUCTION

The National System of Interstate and Defense Highways is the largest undertaking of its kind in history. As early as 1944, the United States Congress called on the States and the Bureau of Public Roads to designate a strategic network of highways to satisfy the requirements of national defense and the national economy. By 1947 most of the routes had been selected, and were approved by the United States Department of Defense. In 1954, the States were asked to make a careful inventory of their highways and to estimate the cost of improving them to a standard that would accommodate the anticipated traffic demands of 1975.

With the passage of the Federal Aid Highway Act of 1956 came the authorization of funds to build the Interstate System. This system will eventually consist of 41,000 miles of controlled-access highways connecting 209 major cities in 48 states and the District of Columbia. The interstate network constitutes only 1.2 per cent of the nation's public road mileage, but when completed, will probably handle 25 per cent of all motor-vehicle travel in the United States.

There are three Interstate Routes in Montana. Interstate Route 90 begins at Lookout Pass on the Montana-Idaho border and generally follows U.S. 10 easterly through Missoula, Butte, Bozeman, and Billings and southerly along U.S. 87 from Billings to the Montana-Wyoming border. Interstate Route 94 begins at Billings and generally follows U.S. 10 through Miles City and Glendive to the Montana-North Dakota border. Interstate Route 15 begins at Monida Pass on the Montana-Idaho border and generally follows U.S. 91 northerly through Dillon, Butte, Helena, Great Falls, and Conrad to the Montana-Canada border. The total length of interstate highway in Montana will be 1200 miles, consisting of approximately 750 miles of two lane and 450 miles of multi-lane highway. The total cost of improvement is expected to exceed $400 million.

This report involves a study of 25.5 miles of Federal Aid Interstate Route 90 from Butte, Montana, on the west to a point on present U.S. 10, approximately 3 miles east of the city limits of Whitehall, Montana on the east. These termini are shown in Exhibit 2. A considerable portion of the study is through extremely mountainous terrain with deep solid rock cuts and high fills, while the remainder of the area is generally rolling in character. Some of the more important features encountered are a high speed interchange with Interstate Route 15, a crossing of the Continental Divide, a bridge over the Northern Pacific Railroad, and an interchange to serve east-west traffic through Whitehall.

The purpose of this report was to make a highway reconnaissance study to determine the most feasible location of Interstate Route 90 between Butte and Whitehall, Montana. The following phases were studied in detail:

1. Geometrics - A complete study of horizontal and vertical alignment for all possible routes through the area was made.

2. Soils and Geology - A photo-geological interpretation was made of the area to determine soil and geological conditions. The results were checked by a field reconnaissance.

3. Hydraulics - A comprehensive study was made to determine major hydraulic considerations including stream relocations, extent of drainage areas and anticipated runoffs, and minor drainage structures required.

4. Bridges - Recommendations were made for the type, length and location of required bridges and major drainage structures.

5. Interchanges - Recommendations were made for the type and location of interchanges.

6. Relocations - Maps are submitted in this report to indicate road closures and relocations, frontage roads, grade separations, and other necessary facilities to serve abutting land owners.

7. Design Standards - Design standards were developed from Montana Highway Commission Standards and AASHO policies.

8. Construction Cost Estimate - Comparable cost estimates for roadway, structures, and right-of-way were made for each route studied with the approximate quantities of the major items included in the estimates.

9. Economic Analysis - A road user benefit analysis was made for each route for the purpose of determining and justifying the final recommended route.

10. Stage Construction - Recommendations were made in this report concerning the stage construction of the project to aid in the preparation of the final plans.

SUMMARY

The purpose of this study was to determine the best possible routing of Interstate Route 90 between Butte and Whitehall, Montana. In order to accomplish this, it was necessary to study all possible locations between those termini taking into consideration the major phases of highway design and construction. Exhibit 1 shows the area under consideration in this report.

In general, AASHO and Montana Highway Department criteria were used to determine the design standards for this study. The design speeds governing all horizontal and vertical curvature were 60 MPH and 50 MPH for the freeway, depending on the type of terrain, and 30 MPH for all ramps, frontage roads, and crossroads. Typical roadway and bridge sections were developed to fit this project, consistent with Montana Standards for Interstate projects.

As shown in Exhibit 2 four feasible routings present themselves between Butte and Whitehall. Two of these, the Rader Creek and Colbert Creek Routes, were eliminated after preliminary study. The other two, the Homestake and Pipestone Pass Routes, were found to be the only routings worthy of further study.

The Homestake and Pipestone Pass Routes were first studied independently in order to determine the best line over each route. Line and grade studies were made, and estimates of earthwork quantities were determined. General studies of soils and geology, traffic, drainage, bridges, interchanges, and right-of-way were performed. Four lines were studied in detail over Homestake Pass, and as shown in Table 1, Line 1-A had the lowest initial cost by approximately one million dollars. Aside from several minor variations, no alignments other than Line 2-A were possible over Pipestone Pass.

Lines 1-A and 2-A were compared on the basis of drainage, bridges, right-of-way, maintenance costs, road user costs, construction costs, and benefit cost ratio. These comparisons are shown in Tables 2 through 11 of this report. These lines were also compared on the basis of over-all length, geometrics, and traffic service. It was found that, although Line 1-A has the disadvantages of generally steeper grades, and slightly higher maintenance and construction costs, it has the advantage of shorter length, better horizontal alignment, lower road user costs, and higher benefit cost ratio. It is recommended that Line 1-A over Homestake Pass be used for the development of contract plans between Butte and Whitehall.

Construction procedures for the recommended line were studied next. As shown in Tables 12, 13 and 14, the recommended line was divided into three contracts, each to be constructed in three stages. These nine separate contracts have been scheduled such that the expenditures will not be excessive in any one fiscal year and yet the proposed improvement can be completed in a reasonable length of time.

DESIGN STANDARDS

The Geometric Design Standards for the National System of Interstate and Defense Highways, adopted July 12, 1956, by the American Association of State Highway Officials, were used as the design criteria in this study. With regard to those features not covered in these standards, the AASHO Policy on Geometric Design of Rural Highways (1954) and current Montana Highway Commission practices were used as guides. The more significant design criteria are as follows:

Design Speed

Freeway - Rolling Terrain	60 M.P.H.
Freeway - Mountainous Terrain	50 M.P.H.
Ramps, Minimum	30 M.P.H.
Frontage Roads, Minimum	30 M.P.H.

Maximum Horizontal Curvature

Freeway - Rolling Terrain	5° 00'
Freeway - Mountainous Terrain	6° 30'
Ramps and Frontage Roads	25° 00'

Spirals

Freeway	All curves 1° 30' or Sharper
Ramps and Frontage Roads	None Required

Maximum Grades

Freeway - Rolling Terrain	4%
Freeway - Mountainous Terrain	7%
Ramps, Moderate to High Volumes	5%
Ramps, Low Volumes	10%
Frontage Roads	10%

Crest Vertical Curves

As outlined by AASHO with the following minimum lengths:

Freeway	800'
Ramp	200'
Frontage Road	200'

Sag Vertical Curves

As outlined by AASHO with the following minimum lengths:

Freeway	600'
Ramp	150'
Frontage Road	100'

Superelevation

As outlined by AASHO with a maximum of 0.08 feet per foot on the freeway, ramps, and frontage roads.

Superelevation Runoff

Superelevation runoff ratios as outlined by AASHO.

Lane, Shoulder, and Median Widths

See Roadway Sections - Exhibit 3

Number of Lanes

From Butte to east of Whitehall Interchange	4 Lanes
From Whitehall Interchange to end of project	2 Lanes

Fill Slopes

0 - 5' Fill	5:1
5 - 10' Fill	4:1
10 - 15' Fill	3:1
Over 15' Fill	2:1

Cut Slopes

0 - 5' Cut	5:1
5 - 10' Cut	4:1
10 - 15' Cut	3:1
Over 15' Cut	2:1

In Rock - See Roadway Typical Sections - Exhibit 3

Surfacing

See roadway typical sections - Exhibit 3

Drainage Design Criteria

For drainage areas 250 to 10,000 acres -- as outlined in Pages 60 to 67, inclusive, of Montana Highway Department Field and Office Standards, (Tables based on Burkli-Ziegler Formula for 25-year storm).

For drainage areas over 10,000 acres -- special curve reflecting recent runoff experience furnished by Hydraulic Engineer of Montana Highway Department.

Structure Lane and Shoulder Widths

See structure typical sections - Exhibit 4

Minimum Vertical Clearances

Interstate Highway Under	17' - 0"
Primary or Local Highway Under	14' - 4"
Northern Pacific R.R. Under	23' - 0"

Minimum Horizontal Clearances

Interstate Highway Under - Rolling Terrain	4.5' Left & 10.0' Right
Interstate Highway Under - Mountainous Terrain	4.5' Left & 8.0' Right
Primary and Local Highway Under	4.0' Left and Right
Northern Pacific R.R. Under	12.0' from Centerline of Track
Northern Pacific R.R. Roadbed	14.0' from Centerline of Track to toe of slope

Structure Loading

Interstate Highway Structures - H-20 S-16 modified for military vehicles
Primary or Local Highway Structures - H-20 S-16

DESCRIPTION OF ROUTES STUDIED

The Continental Divide is probably the most formidable obstacle to highway design and construction in Montana. Any crossing of this natural barrier usually involves long, steep grades, deep solid rock cuts, and high fills.

Between Butte and Whitehall, there are two comparatively low passes over the Continental Divide. The Northern Pacific Railroad goes by way of the most direct route over Homestake Pass. The Milwaukee Railroad and present U.S. Highway 10 traverse a more southerly and somewhat less direct route over Pipestone Pass. A preliminary study of airphotos of the area, coupled with a field reconnaissance, indicated that all other crossings were either too high or too circuitous and offered almost insurmountable topographic difficulties. Therefore, as shown in Exhibit 2, only routings over Homestake and Pipestone Passes were considered in this report.

Homestake Pass Route

The most direct route between Butte and Whitehall is over Homestake Pass, shown as Route 1 on Exhibit 2. This line generally follows and remains south of the Northern Pacific Railroad from Butte to approximately 5-1/2 miles west of Whitehall. In addition, it remains south of Homestake Creek from 1-1/2 miles east of the Continental Divide to a point where that stream flows into Big Pipestone Creek. From 5-1/2 miles west of Whitehall to the Whitehall Interchange, the line remains north of the county road on the range line between T1N and T2N.

The main features of the Homestake Pass Route are as follows:

1. Length - This is the shortest of all routes studied with only 22 miles between Butte and Whitehall.

2. Interchanges - There are four interchanges on this route. The locations of these interchanges are shown in Exhibit 2.

3. Structures - There are 5 grade separation structures and 1 major drainage structure on this route. This does not include interchange structures.

4. Traffic Service - There are no direct connections to present U.S. 10 between Butte and Whitehall and no direct connection to Montana Route 41 which provides service to southern Montana and Yellowstone Park. Local traffic between Butte and White-hall will continue to use present U.S. 10. Interstate traffic wishing to travel south on Montana Route 41 will have access to this route though the interchange at Station 846+50 provided that the existing connecting roads are improved as mentioned under Final Line Comparison in this report.

5. Frontage Roads - Since this route generally passes through a very sparsely settled area and does not replace or closely parallel any major highways, frontage roads will be kept to an absolute minimum. However, since the interstate highway will be constructed in addition to and not in place of present U.S. 10, the existing facility will have to be maintained as a primary high-way.

6. Right of Way - Since this route is mostly through wilderness area or isolated grazing land, right of way is a minor considera-tion.

7. Detouring of Traffic during Construction - Since this route is completely separate from present U.S. 10, detouring of traffic during construction will be no problem.

8. Usability of Freeway during Stage Construction - Since this route is completely separate from present U.S. 10 and does not intersect any high-type highways between the termini, a large portion of the freeway, namely from Butte to Pipestone Hot Springs, will not be usable until the last stage of construction is complete on that portion.

Pipestone Pass Route

The most indirect route, but the route serving the most local traffic is over Pipestone Pass, designated on Exhibit 2 as Route 2. This line generally follows the so-called "Nine-Mile Road" from Butte to a point where that facility connects with present U.S. 10. From that point to approximately 5 miles west of Whitehall, it generally follows present U.S. 10. There it diverges from the existing highway and joins the Home-stake Pass Route approximately four miles west of Whitehall.

The main features of the Pipestone Pass Route are as follows:

1. Length - This is the longest of all routes studied with approximately 27 miles between Butte and Whitehall.

2. Interchanges - There are five interchanges on this route. The locations of these interchanges are shown on Exhibit 2.

3. Structures - There are 6 grade separation structures and 2 major drainage structures on this route. This does not include interchange structures.

4. Traffic Service - This route will serve more local traffic than the other routes studied mainly because it will directly replace a very large portion of present U.S. 10 between Butte and Whitehall. It will connect directly with Montana Route 41 by means of an interchange, but will require extensive use of frontage roads to serve all of the people now being served by the present highway.

5. Frontage Roads - Since this route generally follows present U.S. 10, frontage roads to serve adjacent property owners will necessarily be a major consideration. Large portions of the existing highway will remain in place, not only as a traffic detour during construction, but also as a permanent frontage road after construction. At certain locations, frontage roads will be needed on both sides of the freeway.

6. Right of Way - Due partially to its proximity to present U.S. 10 and partially to the expensive irrigated land through which it passes, the right of way will be a major consideration. Several roadhouses and complete homesteads, some isolated outbuildings, and rather extensive irrigation facilities will have to be removed and/or relocated. Severance damages in certain locations will be high. In all, the right of way costs for this route will be by far the highest of any route studied.

7. Detouring of Traffic during Construction - Since this route is adjacent to present U.S. 10 for a large portion of the project, maintaining reasonable traffic service will be a major consideration. Large portions of present U.S. 10 will be kept in place as a frontage road to serve abutting land owners. However, even in those areas where present U.S. 10 is preserved, conflicts between highway motor vehicles and construction equipment will definitely result in reduced speeds for through traffic and construction delays for the contractors.

8. Usability of Freeway during Stage Construction - The Pipestone Pass route offers maximum usability of completed portions of the freeway during stage construction because of its close proximity to present U.S. 10. Connections to the existing highway will be quite short, direct, and inexpensive at almost any point.

Rader Creek Route

An alternate alignment that combines some of the features of both the Homestake Pass and Pipestone Pass lines is the so-called Rader Creek Route, designated as Route 3 on Exhibit 2. It is coincident with the Homestake Pass Route from Butte to approximately two miles east of the Continental Divide. At that point it diverges to the south and follows an existing jeep trail for about four miles and then follows Rader Creek to its intersection with the Pipestone Pass Route approximately one mile west of the Montana Route 41 intersection. Thence it follows the Pipestone Pass Route to the end of the project.

With the exception of its direct service to Montana Route 41 and an additional length of two miles, this route has all the characteristics of the Homestake Pass Route. In addition, a careful analysis of the route through airphotos and in the field revealed that the terrain is more rugged than that of the Homestake Pass Route, and the problem of developing a reasonable grade down the east side of the Continental Divide is much more difficult than either of the other routes.

Considering these facts, it was decided that the Rader Creek Route could be eliminated without further study.

Colbert Creek Route

A variation of the line over Rader Creek is the so-called Colbert Creek Route, designated as Route 4 on Exhibit 2. It is coincident with the Rader Creek alignment to where that route crosses the range line between T2N and T1N. At that point it diverges to the east and follows Colbert Creek to its intersection with the Pipestone Pass Route approximately one mile east of the Montana Route 41 Intersection. Thence it follows the Pipestone Pass Route to the end of the project.

This line is slightly shorter than the Rader Creek Route. Also, as shown in Exhibit 2, its service to Montana Route 41 is not as direct as the more southerly route. Otherwise, the line has all the characteristics of the Rader Creek Route, and for the same reasons, was eliminated without further study.

GENERAL PROCEDURE

The Interstate Division of the Montana Highway Department prepared detailed topographic maps at 1" = 200' with a 20 foot contour interval of both the Homestake and Pipestone Pass Routes. These maps were furnished to Meissner Engineers for line and grade studies of both routes. Profiles were plotted for all lines, and preliminary cut and fill quantities were determined by means of curves that related earthwork volumes to depth of cut, height of fill, and per cent of cross slope. On the basis of volumes of cut and fill developed in this manner, the least feasible lines were eliminated. For the several lines on each route chosen for further study, cross-sections were taken at appropriate intervals and entered into a Bendix G-15 electronic computer along with grades and roadway typical sections. Earthwork volumes were thus obtained with both speed and accuracy. It was possible using this procedure to approximately balance cuts and fills on several different lines with a minimum of time and effort.

General soils and geological studies of the area were performed on 1:20,000 airphotos obtained from the U.S. Forest Service. Detailed studies on the Homestake and Pipestone Pass Routes were made using 1:12,000 airphotos furnished by the Interstate Division of the Montana Highway Department. The results of these studies were thoroughly checked in the field and are presented elsewhere in this report.

Since traffic volumes through the study area are expected to be fairly low, even in 1975, the study of traffic in relation to freeway and interchange capacity was not a major consideration. However, for road user costs, the determination of approximate present and future traffic volumes was considered to be very important because of the difference in traffic service provided by each route studied. The latest origin-destination data for the study area were furnished by the Montana Highway Department along with a suitable factor for the expansion of traffic to 1975. This information was analyzed and present and future traffic assignments were made to the various routes studied.

After a thorough search, it was found that very little stream flow information was available for the study of drainage, and interviews with long-time residents of the area failed to produce sufficient data for a comprehensive drainage study. It was, therefore, necessary to approach the drainage de sign through empirical means.

For the initial drainage computations, it was decided to try Talbot's formula using a maximum rainfall of one inch per hour and the recommended runoff index for the various types of terrain encountered. Using a runoff index of 0.3 to 0.6 for mountainous terrain, depending on the slope of the drainage area, culvert sizes were obtained which agreed reasonably with the sizes of existing structures in the area.

Further problems were encountered for drainage areas over ten square miles. Using the data given in the 1958 U.S. Geological Survey publication, "Surface Water Supply of the United States, Part 6-A, Missouri River Basin above Sioux City, Iowa", the sizes of drainage areas of the various streams in or near the study area were plotted in relation to their maximum discharges on log-log graph paper. By approximately fitting these points with a straight line, a runoff curve was obtained that could be used for large areas.

A comparison of runoffs from minor and major drainage areas obtained in these independent studies with those determined by present Montana Highway Department methods indicated a fairly close agreement. In view of this, it was decided that the procedures presently used in Montana should be used in this study.

Therefore, for areas up to 10,000 acres, the data given on Pages 60 to 67 inclusive of the Montana Highway Department Field and Office Standards were used to determine drainage structure sizes. For the areas over 10,000 acres, a special curve, reflecting recent runoff experience was furnished by the Hydraulic Engineer of the Montana Highway Department. By planimetering the drainage basins shown on advance quad sheets furnished by the U.S. Forest Service, it was possible to obtain approximate drainage areas from which probable stream flows could be computed. The types of ground cover in the different areas were obtained from the 1:20,000 air-photos. Table 2 gives the sizes of all major drainage areas and the location and size of each drainage structure 42 inches or more in diameter for Lines 1-A and 2-A. It was felt that culverts less than 42 inches in diameter represented such a minor part of the total construction cost that they could be handled on a per mile basis.

In order to determine drainage costs that would be as conservative as possible for both Lines 1-A and 2-A, the sizes of culverts draining areas over 10,000 acres were determined to allow no build-up of head at the inlet end, a procedure which resulted in the maximum possible culvert sizes. For final design, it is recommended that the pipe locations in question be investigated further in an effort to reduce the size and cost of those installations.

Major structures were a consideration in all the preliminary line and grade studies since they control both horizontal and vertical alignment to a certain extent on most locations. However, it was not until a so-called "best" line was set on each of the two preferred routes that they were studied in detail. Information concerning horizontal and vertical clearances at structures, current design standards, and drawings reflecting present design practices were furnished by the Bridge Division of the Montana Highway Department and were used throughout in determining types and lengths of all major structures. Unit prices per square foot of deck area were computed from bridge plans furnished by the same organization and were used for the determination of major structure costs. The bridge typical sections used in this study are shown in Exhibit 4, and Table 3 lists all the pertinent factors, including total cost, for all major structures on Lines 1-A and 2-A. Bridges are discussed in detail elsewhere in this report.

General interchange locations were determined for all routes on the basis of traffic service before any detailed line and grade studies were made. In the final geometric studies, horizontal and vertical alignments were used that would facilitate interchange designs at those locations. After Lines 1-A and 2-A were established as the best routings over Homestake and Pipestone Passes, traffic and geometric studies were made at each interchange location on both lines to determine type of facility, crossroad and ramp geometrics, and grading and surfacing quantities.

Right-of-Way was not a major consideration in the preliminary line and grade studies. However, in the final line selection, it was a major item because of the difference in present land use between the Homestake Pass Route and the Pipestone Pass Route. In general, it was assumed that a 300 foot strip would be acquired except in those areas where deep cuts and fills, frontage roads, or interchanges dictated wider strips of right-of-way.

The county agents of Jefferson and Silver Bow Counties were contacted in regard to reasonable market values for the various types of land in the study area. Also, assessed valuations were obtained in the county offices and converted to real valuations using the current conversion factors in use. Finally, records of recent land sales in both counties were investigated in an attempt to determine current market values of land. The valuations obtained by these three methods were compared and a reasonable set of values were determined. Where buildings were taken, access cut-off, or properties severed, values were set for damages that were considered fair or equitable. Table 4 gives the total right-of-way costs for Lines 1-A and 2-A along with a detailed tabulation to indicate how they were determined.

Access problems were studied in detail on both routes, and where possible, were resolved by means of frontage roads, separation structures, or interchanges. Where it was not possible or economical to provide service by some means, values were added to the right-of-way costs.

Clearing and grubbing were not considered in the preliminary line and grade studies. They were, however, important considerations in the final choice of line because of the great abundance of trees and undergrowth on both routes. In general, it was assumed that the entire right-of-way width would be cleared. The airphotos used in the soil and geological studies were used to determine the limits of the areas to be cleared.

The compilation of construction cost estimates was accomplished in three phases, as follows:

1. For preliminary line and grade studies on the Homestake Pass and Pipestone Pass Routes, only estimates of grading quantities were made and the least desirable lines eliminated on the basis of that alone.

2. For the determination of the so-called "best" line on each of the preferred routes, construction cost estimates including all pertinent items were compiled. Those items that would be approximately the same for all lines on one route were not included.

3. For the final determination of the best possible line through the study area, complete construction cost estimates were compiled and used in the benefit cost analysis.

The average low bid prices for highway construction projects for calendar year 1959 as compiled by the Office Engineer of the Montana Highway Department were used in the preparation of all estimates. Construction cost estimates are discussed in detail elsewhere in this report.

Since a large majority of the study was in a rural area, utilities were not a major problem. However, telephone, telegraph, power lines and gas and oil pipe lines, all of which bisect the area, were avoided where possible. Where they were disturbed, approximate costs of relocation were determined and included in the cost estimates for both Lines 1-A and 2-A.

Lighting and signing were not considered to be a portion of the study. However, lump sums for these items were included in the cost estimates in order to make them as complete as possible.

Maintenance costs were a major consideration in the final determination of the best possible line between Butte and Whitehall. In order to arrive at reasonable values, highway department maintenance divisions of several western states in the Rocky Mountain area were contacted and average annual maintenance costs for various types of highways obtained. Fairly close agreement was found between these values and current average costs in Montana; therefore, it was decided to use the Montana maintenance costs. Accordingly, those values were applied to the so-called "best" line on each of the preferred routes, and maintenance costs were determined for the freeway, all frontage roads and all primary highways necessary to serve traffic that would normally operate on U.S. Highway 10 through the study area. Table 5 gives the total maintenance costs for both Lines 1-A and 2-A along with detailed tabulation to indicate how they were determined.

A benefit cost study was performed to determine the best possible alignment between Butte and Whitehall. In order to accomplish this, it was necessary to compute road user costs on both lines for all traffic using the freeway, frontage roads, and primary highways that would normally travel on U.S. Highway 10 through the study area. The road user costs as shown in the 1960 AASHO publication, "Informational Report by Committee on Planning and Design Policies on Road User Benefit Analysis for Highway Improvements", were used with only one exception. To reflect the much higher cost of gasoline in Montana, 38¢ per gallon was used for the fuel cost instead of 32¢ as shown in the report. Because of the steadily increasing traffic volumes on the interstate highways between 1956, the year the current program was started, and 1975, the design year for this program, an average of the traffic volumes for those two years was used to compute the road user costs. Tables 6, 7 and 8 give the total road user costs for Line 1-A, Line 2-A, and present U.S. 10 respectively, along with detailed tabulations to indicate how they were determined. The procedures as outlined in the AASHO publication were used to determine the benefit cost ratios of both lines in relation to present U.S. Highway 10.

After the best possible line between Butte and Whitehall was determined, a study was made to find out the most logical procedure for construction of the freeway. The final line was divided into three projects of reasonable length and cost, and these projects were further separated into several stages, all for the purpose of programming the proposed improvement for construction. An attempt was then made to arrive at a reasonable construction schedule that would fit into the future highway improvement program of the area.

ANALYSIS OF ROUTES

Preliminary studies indicated that the Homestake Pass and Pipestone Pass Routes were the only two routes worthy of further study. It was then necessary to study a variety of lines in detail in order to arrive at the best alignment for each route. A comparison could then be made between the routes, in order to determine the best possible line between Butte and Whitehall.

Typical Sections

The Interstate Division of the Montana Highway Department has developed typical roadway sections which are standard for all interstate projects. These sections were used exclusively to develop typical sections for this study. However, since they are of a general nature, it was necessary to make certain basic decisions concerning median width and type, shoulder width, number of lanes, type of surfacing, and steepness of cut and fill slopes.

Three different median widths were used in this study. The Butte Urban Project is being designed with a 36 foot median at its east end. This median width was continued to the beginning of the mountainous terrain because of the rolling, suburban character of the countryside through this area. For the extremely mountainous terrain over the Continental Divide, a narrow median was required. The minimum desirable median width for traffic of the nature being considered here is 8 feet. Therefore, an 8 foot flush median is recommended through the mountainous terrain of this project. A 46 foot median was used at the east end of the project because of the rolling, rural character of this section. Also, a 46 foot median is very close to the minimum width for the elimination of headlight interference between opposing vehicles and is compatible with present Montana Highway Department design standards.

The 36 and 46 foot medians used for the sections of the beginning and end of the study were considered to be wide enough for the use of a simple depressed median. For the narrow median typical section through the mountainous area, a barrier consisting of a double line of steel guard rail was recommended to separate the opposing lanes of traffic. This is compatible with present Montana Highway Department design practice. However, it is felt that serious consideration should be given to a flush median

with no barrier of any sort between opposing traffic lanes for the final design. Deep snow and blizzard conditions are common in this area during the winter; therefore, a flush median should facilitate faster snow removal. It has been shown on the Donner Pass Highway in California and the Snoqualmie Pass Highway in Washington that a flush median does not necessarily increase accident occurrence when traffic volumes are moderate.

Full ten foot shoulders were used for the wide median sections because neither right-of-way nor heavy earthwork is a problem in these areas. However, six foot shoulders were recommended for the narrow median section because of the extremely mountainous terrain through this area. Their use is justified from a traffic standpoint because the projected 1975 traffic volumes are moderate.

In order to determine the number of traffic lanes required for the various sections of the project, it was necessary to determine the percentage of trucks in relation to total traffic and the relationship of the design hourly volume to the annual average daily traffic. Presently, due to adverse traffic conditions and the numerous towns and cities on U.S. Highway 10, truck drivers wishing to travel to western Montana tend to avoid that facility, if possible. However, when Interstate Route 90 is completed across the State, it seems logical that truck drivers anywhere in the area wishing to travel east or west will tend to gravitate to that facility because of the inherent high design standards and control of access. Therefore, the percentage of trucks can be expected to rise quite appreciably before the year 1975. Accordingly, it was felt that a value of at least 15% would be reasonable. Also, since Montana is rapidly becoming a major vacation center of the Northwest, heavy seasonal tourist travel through the area can be expected to produce fairly high rural design hourly volumes; therefore, it was assumed that by the year 1975 the DHV would be at least 15% of the ADT. Both of these percentages are in line with present AASHO recommendations for rural highways. Applying these values to the 1975 traffic volumes used in this study, it was found that four lanes are needed from Butte to Whitehall and two lanes from Whitehall to the end of the project.

For the purpose of determining construction cost estimates to be used in this report, asphalt surfacing has been used throughout this project. In the Rocky Mountain states it has been common practice to use concrete pavement through urban areas where periodic maintenance would be a problem because of heavy traffic and asphalt pavement in the rural areas where traffic volumes are low. Since the area through which the proposed freeway passes is primarily rural and traffic volumes are and will continue to be low, asphalt surfacing was used for the entire improvement.

For cuts and fills through normal areas, Montana Highway Department standard cut and fill slopes were used. Through the mountainous area where cuts and fills would be deep and solid rock plentiful, it was necessary to use special slopes. The geological study indicated that, in general, cut slopes 3/4:1 or steeper would stand with proper benching. Also, with reasonable care in the placement of rock embankment during construction, fill slopes at least as steep as 1 3/4:1 could be used. Therefore, for this study, 3/4:1 cut slopes with benching and 1 3/4:1 fill slopes were used throughout the mountainous area. However, for final design, further study will be required for the determination of proper cut slopes because the material throughout the mountainous area is weathered, faulted, and jointed. This is especially true on the west slope of the Continental Divide.

The roadway typical sections used in this study are shown in Exhibit 3. The thickness of the upper surfacing courses and type of surface treatment on both the freeway and the ramps are standard for all interstate projects in Montana. For estimating purposes, the thickness of the base surfacing was assumed to be 1.50 feet for the freeway and 1.00 feet for the ramps. These values are well in accord with current design practices in Montana and represent reasonable average thicknesses.

Interchanges

Freeways are by definition limited access facilities. Therefore, both interchange location and type are very important because there will be no other points of access.

After careful study, the following interchanges were recommended for the Homestake Pass Route:

1. A trumpet interchange east of Butte to connect Interstate Routes 15 and 90;

2. A diamond interchange at the Rader Creek Road crossing to serve all the ranches, mines, and recreational areas on the near east side of the Continental Divide;

3. A diamond interchange north of Pipestone Hot Springs to serve the agricultural area west of Whitehall;

4. A diamond interchange north of Whitehall to serve that town and the immediate vicinity.

The interchange between Interstate Routes 15 and 90 and the Whitehall Interchange are common to all routes studied. After careful study, the following additional interchanges were recommended for the Pipestone Pass Route:

1. A diamond interchange near the intersection of the Nine-Mile Road and present U.S. 10 to serve all of suburban southeast Butte;

2. A diamond interchange at the intersection of the Rader Creek Road and present U.S. 10 to serve the ranches, summer homes, and recreational areas on the near east side of the Continental Divide;

3. A diamond interchange at the intersection of Montana Route 41 and present U.S. 10 to serve the agricultural area west of Whitehall and all of southern Montana via Montana Route 41.

The comparatively low traffic volumes predicted for all interchanges on both routes warranted the recommendation of the simplest and least expensive applicable types throughout. Also, because it is the intersection of two limited access highways, a free-flowing, high speed facility was considered necessary for the interchange between Interstate Routes 15 and 90 east of Butte. Therefore, a trumpet interchange was recommended for that location and diamond interchanges for all others.

Location Controls

For detailed study, the following controls were established:

1. The line should tie into the end of the Butte Urban Interstate Project, now under design, immediately west of Continental Divide.

2. On the Homestake Pass Route, multiple crossings of the Northern Pacific Railroad should be avoided.

3. On the Pipestone Pass Route, crossing of the Milwaukee Railroad should be avoided.

4. On both lines, the Continental Divide should be crossed in the lowest possible area.

5. The line should tie into present U.S. 10 east of Whitehall at some point in or near Section 6, T1N, R3W.

Analysis of Homestake Pass Route

The general nature of the terrain over the Homestake Pass Route made it possible to study many different lines. Unlike the Pipestone Pass Route, where a deep, narrow canyon leads to the Continental Divide from both sides, a large portion of the Homestake Pass Route, though extremely mountainous, is comparatively level laterally.

Toward the Continental Divide from both the east and the west, four main lines were studied. They are as follows:

1. The best possible line regardless of grade,

2. The line with the shortest possible sustained 5% grade,

3. The line with the shortest possible sustained 6% grade,

4. The line with shortest possible sustained 7% grade.

From Butte to the base of the mountainous area, two main lines were studied; one along the Northern Pacific Railroad, and the other closer to present U.S. 10. From the Pipestone Hot Springs to Whitehall, two main lines were studied, one above the Pipestone Ditch and therefore above the irrigated land, and the other below the Pipestone Ditch and adjacent to U.S. 10. The more important lines that were considered are shown on Exhibits 6 to 15 inclusive and discussed briefly below.

Line 1-A is the best possible blend of terrain and horizontal and vertical alignments. Line 1-B, 1-C and 1-D have respectively the shortest possible 5%, 6%, and 7% grades up to and down from the Continental Divide. Lines 1-E, 1-F, 1-G and 1-H are alternate alignments at various locations which were studied and eliminated because of excessive cost.

Construction cost estimates for Lines 1-A, 1-B, 1-C and 1-D, shown in Table 1, indicated that Line 1-A has the least initial expense, and therefore the preferred alignment over Homestake Pass. It should be noted that preliminary studies indicated that the differences in grade and length of line among the four lines were not significant enough to be considered factors in the analysis.

Analysis of Pipestone Pass Route

For the Homestake Pass Route, there was a comparatively wide choice of lines to be studied. This was not true of the Pipestone Pass Route because of the nature of the terrain.

To reach the Continental Divide from either the east or the west it is necessary to pass through a narrow canyon with steep walls through which presently pass U.S. Highway 10, Blacktail Creek, Little Pipestone Creek, and the Milwaukee Railroad. Also, there are many summer homes that are served only by the present highway and several U.S. Forest Service roads and trails that feed into that facility. Therefore, if a limited access highway is to be constructed over Pipestone Pass, provision also has to be made for a frontage road to serve all those presently served by U.S. Highway 10.

Giving full consideration to the limiting factors discussed above, the Pipestone Pass Route was studied in detail, and Line 2-A was developed as the best possible alignment. In the Continental Divide area, it was possible to study several alternates. Line 2-B was a routing with a 6% grade where Line 2-A has a 7% grade. Lines 2-C and 2-D were attempts to find other possible crossings of the Continental Divide. All of these alternate lines proved to be more expensive than equivalent segments of Line 2-A.

It was considered important in the development of Line 2-A to leave as much of present U.S. 10 intact as possible. Not only would this facilitate the maintenance of traffic, during construction, but the existing highway could serve very adequately as a frontage road after completion of the new facility.

BRIDGES

A review of all the proposed structure sites for this project indicates that conventional structures would satisfy the requirements. There are no long span structures, pedestrian overpasses, railroad structures carrying railroad loadings, movable bridges, tunnels or bridge widening and extensions.

Since these are to be conventional structures, investigations have been restricted to the common deck type bridges such as concrete tee-beam, concrete box girder, prestressed concrete, rolled beam non-composite, rolled beam composite, and welded girder composite.

The over-all dimensions of the structures such as width, height and length have been determined by the roadway and crossing requirements. Since this project is rural in character, open end spans have been used to minimize substructure costs and prevent adverse structural conditions.

Comparison of Bridge Types

Conventional structures have for the most part been standarized and, therefore, major elements such as structural quantities and unit price range have been determined and compared. This procedure was used to check and compare each of the conventional types prior to making any specific recommendation or detailed cost study. It is not possible at this time to accurately predict unit costs at the time of construction; therefore, current prices have been used to make relative comparisons between structure types.

Structure Type Selected

Prestressed concrete superstructures compared favorably with other types on the basis of estimated initial construction cost. Factors other than initial cost, such as maintenance, superstructure depth, and current practices of the State Bridge Department, were also considered.

After evaluating all criteria, prestressed concrete superstructures were used for final cost comparisons for all sites except one. See Table 3.

Unit Prices and Estimated Costs

In order to determine the cost per square foot for deck area, unit costs for major structure quantities were based on current bid prices for comparable structures in the State of Montana. Quantities for similar struc-

tures were based on final structure plans furnished by the Highway Commission. The deck area is defined as the width of the structure measured between curb faces multiplied by length of structure measured between back face of each abutment.

The actual construction costs of most conventional structures has not changed appreciably in recent years, therefore, the costs indicated herein should be reasonably accurate for the next few years.

GEOLOGY

The region under study is located within the Rocky Mountain system of western Montana. The topography varies from the moderately dissected sediments of the intermontane valley on the east to the rugged mountainous terrain of the Boulder Batholith on the west.

From Pre-Cambrian time through late Cretaceous-early Tertiary time, the area was subjected to sedimentation and erosion. At the close of Cretaceous time the dynamic forces of the Laramide Orogeny began. These forces, resulting in the formation of the Rocky Mountains, signaled the beginning of a period of crustal unrest and volcanism, during which time the area was intruded by the Boulder Batholith. The intrusion of this magmatic body resulted in folding and metamorphosis of the rocks at the contact zone.

Presumably, the invasion by the Batholith took place in two stages. The initial stage, occurring east of the Toll Mountain-Bald Mountain area, formed rocks of a granodioritic character. Second stage intrusion resulted in the characteristic quartz-monzonite of the Butte area. Throughout the period of unrest dike-like bodies were intruded into the sediments and igneous rocks. From late Cretaceous through late Tertiary time, uplift and faulting continued. This movement, coupled with erosive forces, has resulted in the structural and topographic features reflected in the area at this time. Minor local variations occur, which represent some glaciation and morainal deposition. Bordering on the east side of the Batholith are sediments of Tertiary age, occasionally capped with gravels of Pleistocene age or broken by Cretaceous volcanics or late Cretaceous volcanics or late Cretaceous-early Tertiary dikes. Recent deposits of alluvium are present along all major streams and several upland valleys, where local base levels have been attained.

Purpose and Method of the Geologic Study

As an aid in determining the most desirable location of the proposed roadway from Butte to Whitehall and for the purpose of establishing a basic knowledge of the soil and rock conditions in the area, a geologic reconnaissance was made of the proposed routes. Aerial photographs to a scale of 1" = 1000' were studied in detail and all apparent and inferred geologic conditions were noted on the contact prints. A field reconnaissance was then made to substantiate the results of photogeologic analysis.

The dominant strike and dip of fractures and joint patterns were estimated geometrically, and the physical characteristics of local formations were noted where possible and recorded. The data obtained from the combined study has been compiled and is presented on an aerial photo-mosaic included as an exhibit in this report.

The general nature of this report prohibits detailed analysis of geologic conditions in many areas. The recognized limitations of photogeologic study and restrictions of the field reconnaissance necessitate estimating geologic boundaries to a degree that is consistent with the detail of this presentation. Further detailed analysis and delineation should be undertaken through a thorough boring program supplemented by an extensive field reconnaissance during the design phase of the proposed roadway.

Results of the Geologic Study

The major portion of the area is composed of either sedimentary or igneous rocks with approximately 50% of the region lacking appreciable soil cover from an engineering standpoint.

The Butte area valley is essentially a down-faulted portion of the main Batholith body. Compound faulting is exposed in a zone several hundred feet wide along the East Ridge, with the most severe faulting and alteration having occurred east and north of Butte. Movement along this zone was on the order of many hundreds of feet, but the faults and fractures are thoroughly healed at this time. It is in this down-faulted region that the major portion of true soils are located. Valley fill, talus, and alluvium have accumulated to great depths in the form of silty sands. These sands are particles of weathered quartz monzonite washed into the valley from the bordering mountains.

The soils occur, intermixed with quartz monzonite boulders near the contact area, to the outcrop portions of the slope to the east and to the foothills of the Batholith mountains to the south. These low foothills are a portion of the Batholith body and are basically a quartz monzonite. They are remnants of the upper portion of the mass and are an extremely soft rock, breaking down readily to a medium to coarse sand. These elements combine to give a subdued form to the expressions of this type of rock. Soil cover on this material is relatively thick except were occasional inclusions of more sound rock resist severe weathering.

The main body of the Batholith extends eastward to the northeast-southwest trending ridge, terminating at Toll Mountain. It is almost entirely a quartz monzonite. This igneous mass of late Cretaceous-early Tertiary age is broken only by infrequent dikes of aplite or pegmatite, intruded into the main mass. The most striking characteristic of the entire Batholith is the distinct joint pattern. The entire mass is dissected by thousands of joints, the most dominant of which appear to strike N10° W and due east-west. These two patterns exhibit an extremely consistent, essentially vertical dip and persist throughout. In some areas extremely low angle joint patterns are apparent, one set of which occurs along Homestake Creek, approximately 2.8 miles west of Whiskey Gulch.

Although the quartz monzonite is relatively uniform throughout the west portion of the mass, an old erosion surface exists across the western-most 3 to 4 miles of the Batholith. The upper portions of the rock in this area can be expected to break down readily to sands upon exposure. Lower portions of the mass (near major stream channel elevations) can be expected to be much more sound and resistant to weathering. East of the erosion surface the entire quartz monzonite phase is expected to be more competent and soil cover should be very thin.

The eastern terminus of the true monzonite phase of the Batholith lies approximately at the base of the family of northeast-southwest trending ridges previously mentioned. These ridges are formed by Pre-Cambrian and Cambrian sediment remnants, separated by a pre-intrusion fault of large displacement. The sediments have been extremely folded and metamorphosed by the intrusion of the underlying Batholith and are probably more accurately termed meta-sediments.

Metamorphosed Pre-Cambrian sediments are confined to the west slope of the ridge line in the form of folded and meta-hardened shales and siltstones. Remnants of Cretaceous volcanics are present, as are minor pegmatitic dikes. On the east slope of the ridge are metamorphosed quartzites, marbles, dolomites and abundant volcanics. All of these rocks are strongly altered and re-crystalized and are crossed by numerous aplitic and pegmatitic dikes.

Lying to the east of this ridge line and extending to the area of Montana Route 41 along existing U.S. Route 10 on the southeast and to the vicinity of Whiskey Gulch on the northeast is the granodiorite phase of the Batholith. This portion of the Batholith is apparently more sound and durable than the quartz monzonite phase. However, these rocks appear to be crossed and intruded more extensively by aplite and pegmatite dike materials. In addition, some hydrothermal alteration and mineralization has occurred in and north of the Grace area. For the most part overburden soils are relatively thin, except along faulted zones and in areas altered by mineralization or other hydrothermal activity.

Along U.S. 10 in an area 1.5 miles west of Montana Route 41, particuarly along the south side of Little Pipestone Creek, Pleistocene gravels cap the granodiorite rocks and some of the sediments to the east. These morainal deposits are relatively clean gravels and sands occurring to depths averaging from 10 to 15 feet.

In the vicinity of Whiskey Gulch are two minor deposits of a boulder-sand material of unknown origin. These deposits have the appearance of being morainal, but no evidence of glaciation is present in the particular region. Therefore, it is presumed that the deposits are terrace remains or other stream worked remnants of Pleistocene or later time.

North of Big Pipestone Creek and along Dry Creek are Cretaceous volcanic rocks. These dark colored basic rocks have been altered to some degree along the Batholith contact zone. It is, therefore, difficult to differentiate between possible gabbro and basalt rocks. Overburden soils in this geologic formation are extremely thin and gravelly, indicating relatively good soundness and resistance to weathering of individual particles. Jointing and healed fracturing are quite severe.

Two general types of formations extend throughout the remainder of the area under study. The most recent of these, Quaternary alluvium, occurs along the major streams, and for the most part, appears to be composed of fine sands and silts to varying depths with occasional deposits of gravels and clays. Upland alluvial soils are predominantly boulder gravels of Batholith material with frequent sand and silt concentrations in broad, basin-like stream-fed lakes.

The remaining formation, Tertiary sediments, extends from the east Batholith edge throughout the plateau regions to the eastern-most portion of the area. The Tertiary sediments are very weakly cemented and poorly consolidated sands, silts, water-laid tuff, and conglomerates. They are complexly interlayered, and for the most part are predominantly silty and tuffaceous. The more sandy and conglomeratic deposits occur mainly between the east Batholith edge and the junction of Big and Little Pipestone Creeks under a thin veneer of water deposited silt of possible tuffaceous character. The boulders and gravels of this conglomerate are composed of granodiorite, monzonite, basalt, gabbro, brecciated lavas, and consolidated sediments.

Eastward from the terminus of the majority of coarse grained deposits are the silts and sands of the same Lithologic character. These deposits have little cementation and contain occasional gravel and boulder layers and inclusions. The coarse grained inclusions are presumably the results of inter-depositional erosion and subsequent high velocity flow.

Analysis of Routes

From the foregoing discussion, it can be seen that the entire region can be divided into three structural units:

1. The valley fill of the Metropolitan Butte area.

2. The Boulder Batholith with its border conditions and included variations.

3. The region of Tertiary sediments extending from the east Batholith edge through the Whitehall area.

From a preliminary study of the entire area, two topographically feasible routes have been chosen for study. One of these, herein designated as Line 1, utilizes Homestake Pass and follows Homestake and Big Pipestone Creeks to the Whitehall area. The other, designated as Line 2, follows existing U.S. 10 through Pipestone Pass and along Little Pipestone Creek to Whitehall.

Analysis of Line 1

A. Station 9 + 60 to Station 240 + 00

Within these limits the proposed alignment passes from the valley fill area into the altered quartz monzonite and along the west slope of the severely fractured and faulted zone of the Batholith. Thru Station 130 a minimum of cut is required. The major portion of alignment is located on minor fills over valley sands and altered quartz monzonite and its residual sandy soil. From Station 130 through Station 240 the proposed alignment passes through alternate side-hill cuts and fills. The side-hill cuts will be in moderately weathered quartz monzonite, the overlying detrital sandy soil, and the sand-boulder material at the valley fill boundary. The overburden soils will probably vary from one foot to 15 feet in thickness; however, the major portion of rock will probably weather readily on exposure. As a result, shallow cuts should be cut back at ratios of 1:1 to 1 1/2:1 to prevent any subsequent talus build up at their base. Although no deep cuts are anticipated, cuts in excess of 50 feet should be benched at 40 foot intervals. Joints and fractures are moderately extensive in this area, joints generally occurring vertically in two dominant patterns, striking N10° W and due east-west. Subordinate low angle joints and fractures are likely to occur locally and may require additional benching. However, jointing does not appear to present as severe a problem as does the actual condition of the rock.

Since the fills will be located over predominantly granular materials, no difficulties are expected in this respect. Cut soils and rock will serve satisfactorily as embankment materials, as they are all essentially granular and relatively free draining.

B. Station 240 + 00 to Station 430 + 00

Between these limits, Line 1 passes through the severely fractured and faulted zone of the Batholith to an old erosion surface of the quartz monzonite mass. The extremely deep cuts in this area up to Station 340 will be excavated in the weak upper regions of the monzonite. The major portions of this rock weather to a sandy soil very rapidly upon exposure, with natural slopes exhibiting an angle of repose on the order of 35° to 45°. The lower portions of some cuts will probably encounter sound rock which is less susceptible to weathering. In addition, inclusions of sound rock may occur within the mass of softer rock. Considering the sequence of a typical cut in this material, cut slopes on the order of 3/4:1 to 1 1/2:1 should be anticipated with benches located appropriately above and below sound rock inclusions, but never at intervals of greater than 40 feet.

Jointing presumably occurs throughout the area as outlined in the previous section, although the pattern is masked almost completely by the generally extensive weathering taking place. As in the previous section, jointing is not expected to present a severe design problem.

The line crosses three major faults between Stations 250 and 310, but all are completely healed, high angle faults, essentially normal to the line. The degree of alternation at the fault lines is very slight when compared to the over-all condition of the rock. Numerous minor aplitic and pegmatitic dikes and probable subordinate joint patterns occur within the over-all section. The effect of dikes is negligible except for possible silicification and occasional recrystalization. The subordinate joint patterns, if any, are well masked by the active weathering and, if present, may require special benching. Fills over stream channels, gullies, or alluvial areas are not expected to be a problem, in that alluvial soils, as well as available fill materials, are essentially granular and relatively free draining. No side-hill fill stability problems are anticipated at this time because of

apparent present stability to a large degree over the entire area. Noteable is the lack of any appreciable talus deposits within the entire area.

C. Station 430 + 00 to Station 720 + 00

Between the above limits the line maintains cuts averaging less than 50 feet, but several fills are extremely high because of the canyon-like topography. A minor alluvial area is located immediately beyond Station 430. This low area is predominantly cobbles and gravels with some sandy silts and boulders. Beyond this alluvium, the quartz monzonite rock is considerably harder and more resistant than in the previous section. Overburden cover is at a minimum, probably on the order to 2 to 3 feet.

The jointing pattern is very pronounced and is maintained at a close interval. The two dominant patterns described in a previous section, occur extensively throughout the area, particularly east of Station 500. Joints are spaced at 2 to 10 feet intervals on the N10°W striking pattern and at 10 to 30 foot intervals on the east-west striking pattern. A strong, subordinate pattern of low angle south dipping joints or fractures was noted in the vicinity of Station 550.

Since the rock within this area is generally very competent and resistant to weathering, cuts within this section should be satisfactory on a slope of 1/2:1. Benches should be utilized at vertical intervals of 50 feet on south cut faces to allow for possible differential weathering and subsequent rock falls. Because of the apparent south-dipping low angle joints and fractures observed in this area, benching may have to be at a closer interval on north cut faces.

No potential slides or areas of instability are anticipated in fill sections since the observed low dip angle joints and fractures appears to be normal to and dipping into, the alignment sections. However, stability analyses may indicate that side hill benching may be necessary in areas of large side hill fills. Because the rock excavated within this section is expected to be sound, 1 1/2:1 fill slopes appear possible.

D. Station 720 + 00 to Station 800 + 00

At Station 720 the alignment crosses a pre-intrusion fault and the east border of the monzonite phase of the Batholith. The cut at Station 720 passes thru a Cretaceous volcanic deposit of weak

structural character due to extensive fracturing and alteration by the intrusive body. Although structurally weak, the individual rock particles are very competent and should be investigated further as potential base course material. The minor cut through this material should be maintained at a 1/2:1 to 3/4:1 slope. Between this cut and Station 740 the line passes, in fill and minor cut, over Tertiary deposits of sediment gravels capped with sedimentary silt. At Station 740 the line cuts through a boulder-sand deposit of unknown origin, although particles appear to be granodioritic or monzonitic in character. Cut slopes in this material should be maintained at 2:1 to prevent talus accumulation. At Station 800 a small intrusive-extrusive knob of pegmatite and volcanic rock is crossed. The slope in this cut should be maintained at 3/4:1 because of apparent, extensive fracturing. This material also should be investigated for use as select borrow. The remainder of this section is essentially a Tertiary deposit and is covered in greater detail in the following section.

E. Station 800 + 00 to Station 1358 + 00 (End of Project)

From Station 800 through Station 1175 the line passes through poorly consolidated and weakly cemented silts, sands and conglomerates with only minor cuts and fills. Cuts in this material should be treated as cuts through soils, and slopes should be maintained at 2:1 ratios. Embankments should be constructed on 2:1 slopes if on site material is employed.

From Station 1175 to Station 1210 an extensive alluvial deposit of predominantly silt and sand occurs. Fills in this area should offer little difficulty; however, the characteristics of the alluvium should be investigated more thoroughly prior to final design. From Station 1210 through Station 1330, Tertiary silts and sands similar to those previously discussed are traversed, and construction should follow the procedures set forth above. From Station 1330 through the end of the project silty alluvium is again crossed on a fill section.

Analysis of Line 2

A. Station 9 + 60 to Station 310 + 00

Within the above limits the line is maintained on a fill section located over altered monzonitic residual material, valley fill, or alluvium. Since all of the materials are essentially granular and free draining, no special problems are anticipated in this section.

B. Station 310 + 00 to Station 600 + 00

Conditions throughout this section are anticipated to be similar to those of Section B on Line 1. Therefore, cut sections on the order of 3/4:1 to 1 1/2:1 should be anticipated, with benches at approximately 40 foot intervals. Fill sections should offer little or no difficulty.

C. Station 600 + 00 to Station 645 + 00

Conditions within this section appear to be similar to those of Section C of Line 1. However, no appreciable cuts are anticipated and fill sections are minor since the line closely follows existing U.S. 10.

D. Station 645 + 00 to Station 810 + 00

Throughout this section the line closely follows the alignment of existing U.S. 10. This area is one of moderate alteration of the granodiorite phase of the Batholith. Some of this alteration is due to post-intrusive hydro-thermal action, and part is due to the proximity of the contact with the pre-Batholith sediments. The alteration has locally weakened the intrusive mass and allowed relatively extensive erosion and the subsequent development of residual sands. Local pegmatitic and aplitic dikes are present in the vicinity of Stations 760 through 790. However, no cuts are anticipated through the altered zone. Two minor cuts occur, at Stations 700 and 785, and each of these is in essentially unaltered granodiorite. For these cuts, slopes of 1/2:1 are recommended with benching only as required by possible low angle joints or fractures. Fills throughout the section are minor and should be stable. If sound, unaltered granodiorite or pegmatite rock is employed for embankments, slopes of 1 1/2: 1 may be anticipated.

E. Station 810 + 00 to Station 925 + 00

Between the above limits a sound granodiorite rock is traversed by the line. This material is very competent and resistant to weathering, and exhibits a strong compound joint and fracture pattern. Two dominant joint patterns occur at approximately right angles to each other with strikes oriented approximately north-south and east-west and dips approaching 90°. A third joint and fracture system was noted in the vicinity of Station 880.

This system strikes about N40^{o}E and dips at 40^{o} to the southeast. Cuts in this section should maintain slopes of 1/4:1 with benches at 50 foot intervals or less, depending on the local joint system. Fills of sound granodiorite rock may be constructed with slopes of 1 1/2:1. No stability problems are anticipated throughout this section.

F. Station 925 + 00 to End of Project

From Station 925 the line passes through some Pleistocene age gravels overlying Tertiary sediments to Station 975. Beyond Station 975 conditions are similar to those of Section E of Line 1. Throughout this section cuts and fills should be maintained at slopes of 2:1 pending further investigation of subsurface conditions. No stability problems are anticipated throughout the section.

Conclusions

Geologically, the two alternate routes are very similar except for the granodiorite mass crossed by Line 2. Therefore, choice of Line 1 as a preferred route is based primarily on economic and use considerations. The several alternate alignments of Line 1 are also similar in geologic make-up, and the choice of a preferred alignment must be made on cost considerations.

Several conclusions can be made for general consideration. For all cuts in consolidated rock, whether broken or sound, a minimum 12 inch cushion should be maintained beneath sub-base materials. This cushion should be constructed by undercutting the design cut by 12 inches and replacing with a well compacted, suitable sub-grade material. In all deep cuts, seepage will probably occur. In order to prevent hydrostatic uplift pressures from forming beneath the roadway it is recommended that longitudinal underdrains be placed a minimum of 3 feet below drainage ditches throughout the length of cut and be allowed to outfall beyond the cut.

Fills throughout the roadway should be constructed with slopes of 2:1 unless sound, weather-resistant rock is used and foundation conditions permit 1 1/2:1 slopes.

The standard 18 inch sub-base should be adequate for the majority of the roadway section. However, in the silty deposits of the Tertiary sediments

it may be necessary to increase this thickness somewhat to eliminate detrimental frost heave. This, however, should be determined during the testing program associated with the final design investigation.

Select materials for base course aggregate may possibly be obtained at several locations along the alignments. In the vicinity of Whiskey Gulch (Station 720) on Line 1, a basic deposit of volcanics should be investigated further. Although structurally weak, the individual rock appears to be sound and resistant. Immediately to the south of this area is an apparently sound granodiorite that is unlimited in quantity. Portions of the Tertiary gravels can possibly be screened for sound gravel and cobble material that could subsequently be crushed for use. On Line 2 east of Grace, unlimited amounts of granodiorite are available for crushing, as are some pegmatitic dike rocks. Pleistocene gravels are present in the same area and should be investigated further. Within the Butte area, some unaltered quartz monzonites, occurring along the East Ridge, should be investigated further. The majority of alluvial soils are unsatisfactory for use as road aggregate.

Since this report is of a preliminary nature, it should be pointed out that the analysis and recommendations herein presented are only for preliminary studies. The importance of a thorough subsurface investigation program, coupled with an extensive field reconnaissance, prior to final design cannot be overemphasized. The need for a well thought out program of soils and geologic studies is essential to be consistent with good design practices. Such a program should, provide data and bases for safe and economical design of cuts and fills, determine foundation conditions at structure locations for proper design, and aid in determining the most suitable sections to be used for pavement design.

FINAL LINE COMPARISON

In the previous section, it was shown that Lines 1-A and 2- A were found to be the best possible alignments over the Homestake Pass and Pipestone Pass Routes respectively. It was then necessary to make a final comparison to decide which of those two lines was the best possible alignment between Butte and Whitehall. The various comparisons that were made are discussed in the following paragraphs.

Length

There is an appreciable difference in length between the two lines. From the beginning to the end of the study, the lengths are as follows:

Line 1-A	25.54 Miles
Line 2-A	31.42 Miles

It can be readily seen that Line 1-A is 5.88 miles shorter than Line 2-A.

Horizontal Alignment

To determine the relative geometry of one line compared to the other, the following comparisons were made:

1. A summation was made of all central angles on each line without regard to direction or degree of curvature. These were converted to total central angle per mile by use of the mileages in the previous section.

Line 1-A	765° 20' Total Central Angles
Line 2-A	1329° 00' Total Central Angles
Line 1-A	30° 00' Per Mile
Line 2-A	42° 20' Per Mile

2. The total number of curves was tabulated on each line without regard to central angle or degree of curvature. These were converted to the number of curves per mile by use of the mileages in the previous section.

Line 1-A	30 Total Curves
Line 2-A	48 Total Curves

OR

Line 1-A	1.17 Curves Per Mile
Line 2-A	1.53 Curves Per Mile

It can therefore be concluded that Line 1-A is superior to Line 2-A with respect to horizontal alignment.

Vertical Alignment

To determine the degree of steepness of one line in relation to the other, the various grade lengths on each line were tabulated in three classes.

Line 1-A

0-3% Grade	18.14 Miles
3-5% Grade	2.11 Miles
5-7% Grade	5.29 Miles

Line 2-A

0-3% Grade	24.65 Miles
3-5% Grade	3.32 Miles
5-7% Grade	3.45 Miles

The tabulations indicate that the grades on Line 2-A are generally flatter than those on Line 1-A.

Traffic Service

From the point where present U.S. 10 intersects the Butte Urban Interstate Project, shown on Exhibit 2, to the Montana Route 41 junction, the distance via present U.S. 10 is 20.3 miles. The distance between the same two points via Line 1-A is 16.8 miles on the freeway, 3.4 miles on a gravel road, and 1.2 miles on two lane primary highway, or a total distance of 21.4 miles. Also, with the construction of Line 1-A, a large portion of the traffic on present U.S. 10 would be diverted to Interstate 90, thus making travel much easier on the existing highway. Therefore, it is logical to assume that traffic traveling between Butte and Montana Route 41 would continue to use present U.S. 10 even after the construction of Interstate 90 over Homestake Pass. Conversely, Line 2-A serves Montana Route 41 directly and therefore, would automatically absorb the extra traffic.

The Planning Survey Division of the Montana Highway Department furnished the following origin-destination data as 1958 ADT's:

Between Butte and Montana Route 41	383
Between Butte and Whitehall	286
Between Butte and east of Whitehall	1256
From Whitehall East	137

Combining these traffic volumes, the following total 1958 ADT's were obtained:

Between Butte and Montana Route 41	1925
Between Montana Route 41 and Whitehall	1542
From Whitehall East	1393

The Montana Highway Department presently uses an expansion factor of 2.5 to arrive at 1975 traffic volumes in the study area. Using this, the projected 1975 ADT's were obtained:

Between Butte and Montana Route 41	4800
Between Montana Route 41 and Whitehall	3900
From Whitehall East	3500

Using the reasoning outlined previously in this section, the traffic assignment to Line 1-A would be as follows:

	Year	ADT
Butte to Whitehall	1958 -	1542
(Via Interstate 90)	1975 -	3900
Whitehall East	1958 -	1393
(Via Interstate 90)	1975 -	3500
Butte to Montana Route 41	1958 -	383
(Via Present U.S. 10)	1975 -	900

The traffic assignment to Line 2-A would be as follows:

	Year	ADT
Butte to Montana Route 41	1958 -	1925
(Via Interstate 90)	1975 -	4800
Montana Route 41 to Whitehall	1958 -	1542
(Via Interstate 90)	1975 -	3900
Whitehall East	1958 -	1393
(Via Interstate 90)	1975 -	3500

Therefore, Line 2-A has a distinct advantage over Line 1-A because it would carry 23% more traffic by 1975 over a large portion of its length.

However, if the construction of Line 1-A would include the improvement to primary standards of the gravel road connecting the Pipestone Hot Springs Interchange and Montana Route 41, present U.S. 10 would assume the role of a county road for purely local service, and the through traffic presently assigned to it would be diverted to Interstate 90. Therefore, the difference in traffic service between Lines 1-A and 2-A would be eliminated.

Maintenance Costs

It can readily be seen in Table 5 that the maintenance costs for Line 1-A are appreciably more than for Line 2-A. However, a detailed study of that table will indicate that the big difference is in the maintenance of primary highways.

If, with the construction of Line 1-A, it would be possible to include approximately 4.2 miles of primary highway to connect the Pipestone Hot Springs Interchange and Montana Route 41, present U.S. 10 would probably assume the role of a county road. As a result, the mileage of primary highways to be maintained in the study area would be reduced from 29.6 miles to 4.2 miles, thereby reducing the over-all annual maintenance cost on Line 1-A by approximately $46,000.

Road User Costs

The general procedure for obtaining road user costs for Line 1-A, Line 2-A, and present U.S. 10 is outlined in a previous section. It should be noted, however, that 15% trucks were assumed for all lines, and these were converted to equivalent passenger cars using a factor of 3.5. These values are compatible with AASHO recommendations and current Montana Highway Department practice.

As noted in Tables 6 and 7, the road-user costs for Line 1-A are appreciably less than for Line 2-A.

Cost Estimates

For the purpose of estimating the costs of Lines 1-A and 2-A, it was assumed that the project limits would be the limits of this study. None of the improvements on Continental Avenue are included; neither are the west to north and north to west ramps of the interchange between Interstate Route 15 and 90. All of those improvements are being incorporated into the design of the proposed Interstate 15 project from Butte north toward Helena. Detailed estimates for Lines 1-A and 2-A are shown in Tables 9 and 10 respectively and are discussed in detail elsewhere in this report.

It should be noted that 15% of the construction cost was added to allow for the cost of engineering and contingencies. This would include final design surveys, investigation of subsurface conditions; preparation of construction plans, specifications, and contract documents; preparation of construction estimates; bid analysis; general supervision of construction; inspection of materials and workmanship; and the scheduling and coordination of all construction and material contracts. This will also allow for any miscellaneous small items not otherwise included, and for fluctuations in contractor's bids.

A comparison of the cost estimates of the two lines will indicate that Line 1-A is slightly more expensive than Line 2-A.

Benefit Cost Analysis

To determine the capital recovery factor to be used in a benefit cost analysis, it is necessary to have a rate of interest in line with the current rates for conservative investments and a reasonable estimate of the years of life of the facility being analyzed. For this study, a rate of interest at 4% was used, and the years of life for the various highway construction items were assumed to be as follows:

Right-of-Way	50 Years
Grading (Including Excavation, Minor Structures, and Clearing and Grubbing)	40 Years
Surfacing (Including Surfacing, Guardrail, and Signing and Lighting)	20 Years
Major Structures	40 Years

Present U.S. 10 was assumed to be the basic condition and Lines 1-A and 2-A were compared to it. The results of the benefit cost study are shown in Table 11 and indicate that the benefits to be derived from the money to be spent on either Line 1-A or Line 2-A are sufficient to justify the expenditure. However, the benefit cost ratio for Line 1-A is higher than for Line 2-A; therefore, Line 1-A is the more economical of the two routings.

Second Benefit Analysis

To check the results of the benefit cost study, a second benefit analysis was performed. For this study, the basic condition was assumed to be Line 2-A and not present U.S. 10 as was used in the original benefit cost analysis. The results are shown in Table 11 and indicate that the benefits to be derived from the additional money that would be spent on Line 1-A are definitely sufficient to justify the extra expenditure; therefore, Line 1-A, although it has a higher first cost, is the more economical of two lines.

CONSTRUCTION COST ESTIMATES

In order to compile authoritative construction cost estimates for both Line 1-A and 2-A, it was necessary to determine not only accurate total quantities but also reasonable unit prices for the various items in the estimates. The derivation of unit prices is discussed in detail in the following paragraphs.

Clearing and Grubbing

The tabulation of 1959 average low bid prices for Montana highway construction projects lists clearing and grubbing at $1150 per acre. However, this price was based on only 17 acres of clearing and 12 acres of grubbing. Lines 1-A and 2-A have 350 and 150 acres respectively of clearing and grubbing. Therefore, it was felt that a lower unit price should be used to reflect the much greater quantities, and it was determined that $700 per acre would be reasonable.

Excavation

The geological study of the area revealed that, in general, there are three different types of material present. The entire mountainous area is a massive batholith of igneous intrusive rock. West of this formation is a large area of valley fill which was eroded from the edge of the batholith. From this formation east through Whitehall, the area is generally composed of poorly consolidated fresh water sediments.

Although they are of entirely different origin, materials in the areas east and west of the batholith can be considered quite similar in relation to ease of handling during construction. Therefore, for this study materials in both of these areas were designated as Type 1 Excavation and Borrow, and assumed to have the same unit price. The 1959 Montana average low bid prices list excavation unclassified at $0.27 per cubic yard, and it was felt that this would be a reasonable basic price for Type 1 Excavation. To this, $0.13 was added to account for overhaul, watering and rolling, making the total price for Type 1 Excavation $0.40 per cubic yard.

The geological study of the batholith indicated extensive weathering, faulting and jointing throughout. Because of this, all excavation in the area should require no more extreme measures for its removal than is customary for normal hard rock excavation. A check was made with several state

highway departments in the Rocky Mountain area, and it was found that, on an average, the basic cost of removing large quantities of igneous rock is from $0.80 to $1.20 per cubic yard where there is no traffic maintenance involved. Conversely, if there is constant interference of highway traffic, the basic price of rock excavation is as high as $1.60 per cubic yard. Therefore, material throughout the batholith was designated as Type 2 Excavation, and a basic price of $1.10 per cubic yard was assumed. To this, $0.10 was added to account for overhaul, watering and rolling, making the total price for Type 2 Excavation $1.20 per cubic yard. Handling traffic during construction would be a major consideration on Line 2-A because of its close proximity to U.S. Highway 10 through the mountainous area. To account for this in the estimates, $0.30 per cubic yard was added to the Type 2 Excavation unit price determined above, making the total price of that material on Line 2-A $1.50 per cubic yard.

Surfacing

A thorough airphoto study of the soils through the study area, the results of which were checked in the field, failed to reveal any critical major areas where the roadway typical sections as shown in Exhibit 3 would be appreciably changed. Therefore, asphalt and gravel quantities were computed using the surfacing thicknesses as shown in Exhibit 3 and material weights and rates of application that are standard for the State of Montana. These were converted to total surfacing costs per mile by use of the 1959 Montana average low bid prices.

Drainage Costs

For drainage structures over 36 inches in diameter, approximate culvert lengths were actually determined from the contour maps and converted to lump sums using the 1959 Montana average low bid prices.

For culverts 36 inches in diameter or less, a cost of $8000 per mile was assumed. It was felt, that since these would be a very minor portion of the total construction cost, a detailed study of these minor structures would be a part of preliminary and final design.

Miscellaneous Items

Guard rail was installed on all fills over 10 feet in height, and the lengths were determined by careful study of the profiles. The unit price for guard rail was obtained from the 1959 Montana average low bid prices.

Lighting and signing were not considered a part of this study. However, they were included in the cost estimates in order to make them as complete as possible. The following costs were assumed:

Lighting	$50, 000 per interchange
Signing	$10, 000 per interchange

It was also assumed that although all the interchanges would be signed, only the Butte and Whitehall Interchanges would be lighted.

For utility relocations, estimates of the facilities to be moved were made using the topographic maps. These were converted to lump sums using the following costs:

Telephone and Telegraph Poles	$50 Each
Power Poles	$50 Each
Double Power Poles	$200 Each
Encasing Pipe Lines	$30 Per Linear Ft.

From the unit prices presented here complete estimates of cost were compiled for Lines 1-A and 2-A. They are shown in Tables 9 and 10.

ROUTE RECOMMENDATION

By joint analysis of geometric and economic considerations, as well as right-of-way, construction costs, and other features, one of the two alternates, Line 1-A over Homestake Pass or Line 2-A over Pipestone Pass, can now be established as the preferred route. To do so, the lines are evaluated and compared with respect to several major items, discussed in the following paragraphs.

With respect to length, Line 1-A is 5.88 miles shorter than Line 2-A. While length alone cannot be considered an all important factor, it is important to the extent that as long as there is a possibility of a shorter route between two points, there will always be doubt in the minds of the motoring public concerning the wisdom of constructing the longer route.

Concerning horizontal alignment, there is little doubt as to which line is better. Considering the evidence in the previous section, Line 1-A is definitely superior to Line 2-A. Also, the sharpest degree of curvature on Line 1-A is 5° 00' whereas Line 2-A has two 6° 30' curves.

Regarding vertical alignment, Line 2-A is superior because it is generally flatter than Line 1-A. Even more important, Line 2-A does not have the long, steep, sustained grades that are common on Line 1-A.

As regards to traffic service, it was indicated in a previous section that Line 2-A will serve the traffic between Butte and Montana Route 41 whereas Line 1-A will not. However, this difference could be eliminated if, on Line 1-A, Montana Route 41 could be extended to the Pipestone Hot Springs Interchange. Also, although it is a very minor consideration, Line 2-A will carry more purely local traffic due to its close proximity to the farms and ranches in the area.

Many engineers feel that initial cost is the prime consideration for choosing one route over another. In this age of high construction costs, it is certainly an important factor. As shown in Tables 9 and 10, the cost of Line 2-A is \$231,000 less than Line 1-A.

Probably the most important single consideration in choosing a route is the economic analysis. While there are other methods of measuring the benefits in relation to cost, the benefit cost ratio is probably the most universally accepted by highway engineers. As shown in Table 11, Line 1-A

has a higher benefit cost ratio than Line 2-A. The second benefit analysis, the results of which are also shown in Table 11, indicate that the shorter length, better horizontal alignment, and lower road user costs on Line 1-A definitely justify its higher initial cost.

As indicated in Table 4, the right-of-way for Line 1-A is appreciably less expensive than that for Line 2-A. Since this is a minor item when compared to the total cost, it does not assume any real importance unless the type of land being acquired is considered. Line 1-A stays above irrigated land throughout its length whereas Line 2-A passes through the middle of some of the better irrigated land in the area. Considering these advantages to the public, Line 1-A is definitely more desirable than Line 2-A.

Another important consideration is difficulty of construction. Line 1-A can be constructed in its entirety without disturbance of the traffic on present U.S. 10, whereas the close proximity of Line 2-A to that facility will cause constant conflicts with construction equipment and delays for through traffic even in those areas were U.S. 10 is left intact.

Considering the evidence presented here, it appears that Line 1-A is definitely better than Line 2-A. Its disadvantages, such as generally steeper grades, poorer traffic service, and slightly higher maintenance and construction costs are more than balanced by its shorter length, better horizontal alignment, lower road user costs, and higher benefit cost ratio. In addition, the acquisition of right-of-way will probably be easier and faster because it avoids irrigated land, and its construction can be accomplished with absolutely no disruption of traffic on U.S. Highway 10. It is, therefore, recommended that Line 1-A over Homestake Pass be used for the development of contract plans between Butte and Whitehall.

CONSTRUCTION PROCEDURE

After Line 1-A over Homestake Pass was found to be the most feasible route from Butte to Whitehall, it was studied in detail to find the most logical procedure for construction.

The project was first divided into three sections of reasonable length and cost which it was thought would make logical contracts for construction. They are as follows:

1. Contract 1 - From the beginning of the study in Butte to the Rader Creek Road Interchange;

2. Contract 2 - From the Rader Creek Road Interchange to the Pipestone Hot Springs Interchange;

3. Contract 3 - From the Pipestone Hot Springs Interchange to the end of the study east of Whitehall.

It was further separated into three stages of construction; grading and structures, surfacing, and final surface treatment. In this way, nine separate contracts, each of a reasonable length, were possible.

In actually scheduling these nine contracts for construction, it was assumed that, to allow for design and right-of-way acquisition, no construction contracts should be let before July, 1962; that a minimum of 18 months should be allowed for grading and structures contracts; that a minimum of six months should be allowed for surfacing contracts; that, because of possible adverse weather, final surface treatment contracts should not be let before April or after September of any year. Using these criteria, the nine contracts were scheduled such that the expenditures would not be excessive in any one fiscal year and yet the proposed improvement would be completed in a reasonable time. Complete estimates for Contracts 1, 2 and 3 are shown in Tables 12, 13 and 14, respectively. Also, the proposed stage construction recommendations are shown in Table 15.

AREAS REQUIRING FURTHER STUDY

Since the purpose of this report was to determine the most feasible general routing of Interstate Highway 90 from Butte to Whitehall, it is obvious that there are several areas yet to be studied before final design can be started on any phase of the project. Probably the most important phase of study is the actual refinement of the horizontal and vertical alignment of the recommended route. The topographic maps used in this study were necessarily of a general nature since a large area was studied. Therefore, Line 1-A should be used only as a general guide for the final design.

One area in particular which will require much further study is from Station 240 to Station 310. The line in this section climbs the badly weathered west slope of the Boulder Batholith, and with the Northern Pacific Railroad perched above the proposed freeway throughout, cut slopes will be very critical. Detailed geological exploration and a wide band of large scale mapping will be required in order to determine the final line, grade, and cut slopes through the area.

The larger drainage areas should be studied further in an attempt to reduce the culvert sizes. It was explained previously in this report that in order to obtain as conservative an estimate as possible for drainage costs, the larger culverts were designed with no build-up of head at the inlet end. This condition can be modified somewhat, which would probably result in reduced culvert sizes.

The possibility of extending Montana Route 41 north to the Pipestone Hot Springs Interchange should be investigated. A preliminary investigation in this study indicated that it can be justified from a standpoint of economics. Also, it is felt that consideration should be given to a possible improvement of Whitehall Street from the Whitehall Interchange south to present U.S. 10. Although it was not considered in this study, it appears that it would definitely be a desirable improvement.

The soils analysis performed in this study by means of airphotos was necessarily of a very general nature. In order to determine local soil conditions and thus exact typical roadway sections, it will be necessary during final design to make actual field tests throughout the project.

The foundation conditions for all structures were investigated and appeared to be satisfactory. However, deep borings should be taken and plate bearing tests performed at all sites before final design in an effort to determine exact subsurface conditions.

TABLE 1

CONSTRUCTION COST ESTIMATES FOR LINES 1-A, 1-B, 1-C AND 1-D ON HOMESTAKE PASS ROUTE

LINE	1-A	1-B	1-C	1-D
Length (Miles)	25.54	25.69	25.54	25.44
Cost of:				
Grading[1]	$ 9,501,900	$12,489,900	$12,266,700	$10,491,000
Surfacing[2]	3,211,000	3,284,800	3,199,400	3,201,300
Structures	954,500	954,500	954,500	954,500
TOTAL COST	$13,667,400	$16,729,200	$16,420,600	$14,646,800

1. Includes clearing and grubbing, excavation, utilities and drainage.

2. Includes surfacing, guard rail, lighting and signing.

TABLE 2

DRAINAGE RECOMMENDATIONS

LINE 1-A			LINE 2-A		
Station	Drainage Area (Acres)	Culvert Size (Inches)	Station	Drainage Area (Acres)	Culvert Size (Inches)
41+40*	520	48	85+10	890	54
91+10	850	54	123+70	270	42
127+10	250	42	184+50	1,430	66
183+10	690	54	218+10	530	48
202+00	540	48	246+50	260	42
430+60	1,860	66	276+70	14,570	16-7 x 10-1
494+90	2,500	78	291+75	10,790	168
560+90	600	54	306+70	930	60
697+60	43,900	Dbl 132			
739+40	5,730	108	419+90	250	42
784+30	400	48	463+90	5,410	Dbl 84
844+60	1,510	60	544+50	530	48
886+80	1,270	60	640+20	750	54
914+10	1,200	60	691+40	5,500	114
974+25	3,740	60			
976+40	3,740	84	699+00	5,630	114
1034+20*	260	42	769+50	4,320	96
1062+00*	820	54	792+70	340	48
1198+60*	115,600	Bridge	889+10	370	48
1224+80*	430	48	938+70	3,570	90
1248+00*	730	54	1057+60	3,160	90
1273+80*	1,350	60	1236+00	64,700	Bridge
1292+70*	330	42	1275+60	3,740	84

Cost of Major Drainage Structures - Line 1-A $ 520,800
Line 2-A $ 297,500

* Culverts common to Lines 1-A and 2-A

Culverts smaller than 42" in diameter not considered individually.

TABLE 3

BRIDGE RECOMMENDATIONS

Station	Length (Feet)	Deck Width (Feet)	Deck Area (Sq. Ft.)	Cost Per Sq. Ft.	Total Cost
			LINE 1-A		
30+14*	156.0	62.0	9,672	$ 10.50	$ 101,600
50+25*	109.3	76.0	8,307	10.50	87,200
104+75	103.3	76.0	7,851	10.50	82,400
430+60	115.0	68.0	7,820	10.50	82,100
768+50	103.0	76.0	7,828	10.50	82,200
846+50	211.5	28.0	5,922	10.20	60,400
882+00+	259.0	56.0	14,504	12.40	179,900
974+25	113.3	76.0	8,611	10.50	90,400
1180+00*	103.0	76.0	7,828	10.50	82,200
1198+60*	110.0	76.0	8,360	10.50	87,800
1198+60*	64.0	28.0	1,792	10.20	18,300
		TOTAL COST OF BRIDGES			$ 954,500
			LINE 2-A		
105+70	197.5	28.0	5,530	10.20	$ 56,400
291+75	194.3	28.0	5,440	10.20	55,500
388+90	103.0	68.0	7,004	10.50	73,600
510+80	186.0	28.0	5,208	10.20	53,100
779+30	174.5	28.0	4,886	10.20	49,800
1019+10	101.3	76.0	7,699	10.50	80,900
1236+00	142.0	76.0	10,792	10.50	113,300
1250+10	178.8	56.0	10,013	10.50	105,200
1282+50	106.3	76.0	8,079	10.50	84,800
Structures common to Lines 1-A and 2-A					377,000
		TOTAL COST OF BRIDGES			$1,049,600

\+ Plate girder structure. Prestressed Concrete I beams recommended for all other structures on Lines 1-A and 2-A.

* Structures common to Lines 1-A and 2-A.

TABLE 4

RIGHT-OF-WAY COSTS

LINE 1-A

Station	Type of Land	Acreage	Value Per Acre	Total Value
9+60				
	Included in Butte-North Project			
31+00				
	Residential	20.5	$ 1,500	$ 30,800*
54+00				
	Residential	120.9	200	24,200
220+00				
	Grazing	416.4	10	4,200
770+00				
	Dry Farming	151.8	100	15,200
974+00				
	Irrigated	5.5	200	1,100
982+00				
	Dry Farming	16.5	100	1,700
1005+75				
	Dry Farming	31.7	100	3,200*
1052+00				
	Irrigated	12.4	200	2,500*
1070+00				
	Dry Farming	26.2	100	2,600*
1108+00				
	Irrigated	91.9	200	18,400*
1208+00				
	Dry Farming	88.9	100	8,900*
1332+00				
	Irrigated	22.7	200	4,500*
1358+00				
Loss of Access				10,000
Severance Damages				95,000
Buildings to be Removed				10,000
TOTALS		1,005.5		$232,300

* Common to both Lines 1-A and 2-A.

TABLE 4 CONTINUED

RIGHT-OF-WAY COSTS

LINE 2-A

Station	Type of Land	Acreage	Value Per Acre	Total Value
55+20				
	Residential	207.7	$ 200	$ 41,500
306+00				
	Grazing	403.2	10	4,000
942+00				
	Dry Farming	96.8	100	9,700
1032+00				
	Irrigated	111.1	200	22,200
1198+00				
	Dry Farming	37.2	100	3,700
1252+00				
	Irrigated	23.0	200	4,600
1285+00				
	Dry Farming	18.0	100	1,800
1311+25				
Right-of-Way Common to both Lines 1-A and 2-A.		294.5		70,900
Loss of Access				40,000
Severance Damages				80,000
Buildings to be Removed				70,000
TOTALS		1,191.5		$348,400

TABLE 5

MAINTENANCE COSTS

Description of Facility	Length (Miles)	Annual Cost Per Mile	Total Annual Cost
	LINE 1-A		
Interstate Highways*			
4-Lane	23.6	$ 3,500	$ 82,600
2-Lane	2.9	2,000	5,800
Primary Highways*	29.6	1,800	53,300
Cross Roads			
Asphalt	1.1	500	600
Gravel	1.1	200	200
Frontage Roads	4.2	200	800
	62.5		$ 143,300
	LINE 2-A		
Interstate Highways*			
4-Lane	29.5	$ 3,500	$ 103,300
2-Lane	2.9	2,000	5,800
Primary Highways*	7.2	1,800	13,000
Cross Roads			
Asphalt	1.7	500	900
Gravel	0.7	200	100
Frontage Roads	26.3	200	5,300
	68.3		$ 128,400
	PRESENT U.S. 10		
Primary Highways*	32.1	$ 1,800	$ 57,800

* Maintenance costs for Interstate 90 and U.S. 10 were computed from their intersection at the Harrison Avenue Interchange in Butte. (See Exhibit 2).

TABLE 6

ROAD USER COSTS - LINE 1-A

Description of Facility	Length (Miles)	1958 ADT	1975 ADT	Ave. ADT	Equiv. + Pass. Cars	Road User Cost Per Veh. Mile	Total Annual Road User Cost
4-Lane Interstate Highways*							
0-3% Grade	16.2	1,542	3,900	2,720	3,740	$ .0924	$ 2,043,400
3-5% Grade	2.1	1,542	3,900	2,720	3,740	.0959	274,900
5-7% Grade	5.3	1,542	3,900	2,720	3,740	.0982	710,500
2-Lane Interstate Highways							
All 0-3% Grade	2.9	1,393	3,500	2,450	3,370	.0934	333,200
Primary Highways*							
0-3% Grade (Butte)	6.2	1,940	3,200	2,570	3,530	.1123	897,100
0-3% Grade (Whitehall)	1.0	960	1,600	1,280	1,760	.1395	89,600
0-3% Grade	3.0	383	900	640	880	.0933	89,900
3-5% Grade	8.2	383	900	640	880	.1003	264,200
5-7% Grade	2.9	383	900	640	880	.1431	133,300
	47.8						$ 4,836,100

* Road user cost for Interstate 90 and U.S. 10 computed from their intersection at the Harrison Avenue in Butte (See Exhibit 2).

\+ Assume 15% trucks and 1 truck = 3.5 pass. cars (Total Factor = 1.375).

TABLE 7

ROAD USER COSTS - LINE 2-A

Description of Facility	Length (Miles)	1958 ADT	1975 ADT	Ave. ADT	Equiv. + Pass. Cars	Road User Cost Per Veh. Mile	Total Annual Road User Cost
4-Lane Interstate Highways*							
0-3% Grade	13.8	1,925	4,800	3,360	4,620	$ .0924	$ 2,150,200
0-3% Grade	8.9	1,542	3,900	2,720	3,740	.0924	1,122,600
3-5% Grade	3.3	1,925	4,800	3,360	4,620	.0959	533,700
5-7% Grade	3.5	1,925	4,800	3,360	4,620	.0982	579,600
2-Lane Interstate Highways							
All 0-3% Grade	2.9	1,393	3,500	2,450	3,370	.0934	333,200
Primary Highways*							
0-3% Grade (Butte)	6.2	1,940	3,200	2,570	3,530	.1123	897,100
0-3% Grade (Whitehall)	1.0	960	1,600	1,280	1,760	.1395	89,600
	39.6						$ 5,706,000

* Road user cost for Interstate 90 and U.S. 10 computed from their intersection at the Harrison Avenue in Butte (See Exhibit 2).

\+ Assume 15% trucks and 1 truck = 3.5 pass. cars (Total Factor = 1.375).

TABLE 8

ROAD USER COSTS - PRESENT U.S. 10

Description of Facility	Length Miles	1958 ADT	1975 ADT	Ave. ADT	Equiv. + Pass. Cars	Road User Cost Per Veh. Mile	Total Annual Road User Cost
Primary Highways*							
0-3% Grade (Butte)	6.2	3,870	8,000	5,930	8,150	$ .1395	$ 2,572,900
0-3% Grade (Whitehall)	1.0	2,500	5,500	4,000	5,500	.1395	280,100
0-3% Grade	3.0	1,925	4,800	3,360	4,620	.1129	571,200
0-3% Grade	8.3	1,542	3,900	2,720	3,740	.1020	1,155,700
0-3% Grade	2.5	1,393	3,500	2,450	3,370	.1020	313,700
3-5% Grade	8.2	1,925	4,800	3,360	4,620	.1164	1,609,500
5-7% Grade	2.9	1,925	4,800	3,360	4,620	.1574	769,700
	32.1						$ 7,272,800

* Road user cost for Interstate 90 and U.S. 10 computed from their intersection at the Harrison Avenue in Butte (See Exhibit 2).

\+ Assume 15% trucks and 1 truck = 3.5 pass. cars (Total Factor = 1.375).

TABLE 9

COST ESTIMATE

LINE 1-A

Item	Quantity	Unit Price	Cost
Clearing and Grubbing	350 Acres	$ 700	$ 245,000
Type 1 Excavation	3,193,500 C.Y.	0.40	1,277,400
Type 2 Excavation	5,962,000 C.Y.	1.20	7,154,400
Surfacing			
4-Lane - 36' Median	3.93 Miles	104,400	410,300
4-Lane - 8' Median	10.32 Miles	118,700	1,225,000
4-Lane - 46' Median	8.21 Miles	104,400	857,100
2-Lane - Ult. 4-Lane	2.86 Miles	58,700	167,900
Ramps	3.78 Miles	22,000	83,200
Interchange Cross Roads	1.04 Miles	28,700	29,900
Cross Roads and Frontage Roads	4.30 Miles	9,900	42,600
Guard Rail	85,000 L.F.	3.00	255,000
Minor Drainage[1]	25.54 Miles	8,000	204,300
Major Drainage[2]	Lump Sum		520,800
Structures	Lump Sum		954,500
Lighting and Signing	Lump Sum		140,000
Utilities	Lump Sum		100,000
		CONSTRUCTION COST	$13,667,400
Right-of-Way			232,300
Engineering & Contingencies - 15%			2,050,100
		TOTAL ESTIMATED COST	$15,949,800

1. 36" in diameter and under

2. Over 36" in diameter

TABLE 10

COST ESTIMATE

LINE 2-A

Item	Quantity	Unit Price	Cost
Clearing and Grubbing	150 Acres	$ 700	$ 105,000
Type 1 Excavation	3,632,200 C.Y.	0.40	1,452,900
Type 2 Excavation	3,830,400 C.Y.	1.50	5,745,600
Borrow Excavation	777,400 C.Y.	0.40	311,000
Surfacing			
4-Lane - 36' Median	5.55 Miles	104,400	579,400
4-Lane - 8' Median	12.00 Miles	118,700	1,424,400
4-Lane - 46' Median	10.80 Miles	104,400	1,127,500
2-Lane - Ult. 4-Lane	2.86 Miles	58,700	167,900
Ramps	4.70 Miles	22,000	103,400
Interchange Cross Roads	1.32 Miles	28,700	37,900
Cross Roads and Frontage Roads	9.80 Miles	9,900	97,000
Guard Rail	105,000 L.F.	3.00	315,000
Minor Drainage[1]	31.42 Miles	8,000	251,400
Major Drainage[2]	Lump Sum		297,500
Structures	Lump Sum		1,049,600
Lighting and Signing	Lump Sum		150,000
Utilities	Lump Sum		150,000
	CONSTRUCTION COST		$13,365,500
Right-of-Way			348,400
Engineering & Contingencies - 15%			2,004,900
	TOTAL ESTIMATED COST		$15,718,800

1. 36" in diameter and under

2. Over 36" diameter

TABLE 11

BENEFIT COST STUDY

Annual Costs

Line 1-A

Right-of-Way	232,300 x .0465	=	$	10,800
Grading	9,501,900 x .0505	=		479,850
Surfacing	3,211,000 x .0736	=		236,330
Structures	954,500 x .0505	=		48,200
Maintenance				143,300
	TOTAL ANNUAL COST		$	918,480

Line 2-A

Right-of-Way	348,400 x .0465	=	$	16,200
Grading	8,313,400 x .0505	=		419,830
Surfacing	4,002,500 x .0735	=		294,580
Structures	1,049,600 x .0505	=		53,000
Maintenance				128,400
	TOTAL ANNUAL COST		$	912,010

Present U. S. 10

Maintenance Cost	$ 57,800

Road User Costs

Line 1-A	$4,836,100
Line 2-A	5,706,000
Present U. S. 10	7,272,800

Benefit Cost Ratios

Line 1-A over Present U. S. 10 - $\frac{7,272,800 - 4,836,100}{918,480 - 57,800} = 2.83$

Line 2-A over Present U. S. 10 - $\frac{7,272,800 - 5,706,000}{912,010 - 57,800} = 1.83$

Line 1-A over Line 2-A $\frac{5,706,000 - 4,836,100}{918,480 - 912,010} = 134.5$

TABLE 12

COST ESTIMATE

LINE 1-A - CONTRACT 1

Sta. 9 + 60 to Sta. 430 + 60
Length 7.97 Miles

Item	Quantity	Unit Price	Cost
Clearing and Grubbing	142 Acres	$ 700	$ 99,400
Type 1 Excavation	972,040 C.Y.	0.40	388,800
Type 2 Excavation	2,475,200 C.Y.	1.20	2,970,200
Surfacing			
4-Lane - 36' Median	3.93 Miles	99,000	389,100
4-Lane - 8' Median	3.98 Miles	113,900	453,300
4-Lane - 46' Median	-- Miles	99,000	---
2-Lane - Ult. 4-Lane	-- Miles	55,600	---
Ramps	1.73 Miles	20,300	35,100
Interchange Cross Roads	0.39 Miles	26,400	10,300
Cross Roads and Frontage Roads	1.59 Miles	9,900	15,800
Guard Rail	29,360 L.F.	3.00	88,100
Minor Drainage	7.97 Miles	8,000	63,800
Major Drainage	Lump Sum	---	43,400
Structures	Lump Sum	---	271,300
Lighting and Signing	Lump Sum	---	65,000
Utilities	Lump Sum	---	15,400
Final Surface Treatment	Lump Sum	---	44,200
	CONSTRUCTION COST		$ 4,953,200
Right-of-Way			74,200
Engineering & Contingencies - 15%			743,000
	TOTAL ESTIMATED COST		$ 5,770,400

Stages of Construction

1.	Clearing and Grubbing, Excavation, Drainage, Structures and Utilities	$ 3,852,300
2.	Surfacing, Guard Rail, Signing, and Lighting	1,056,700
3.	Final Surface Treatment	44,200
		$ 4,953,200

TABLE 13

COST ESTIMATE

LINE 1-A - CONTRACT 2

Sta. 430 + 60 to Sta. 846 + 50
Length 7.88 Miles

Item	Quantity	Unit Price	Cost
Clearing and Grubbing	203 Acres	$ 700	$ 142,100
Type 1 Excavation	253,330 C.Y.	0.40	101,300
Type 2 Excavation	3,486,800 C.Y.	1.20	4,184,200
Surfacing			
4-Lane - 36' Median	--- Miles	99,000	---
4-Lane - 8' Median	6.34 Miles	113,900	722,100
4-Lane - 46' Median	1.49 Miles	99,000	147,500
2-Lane - Ult. 4-Lane	--- Miles	55,600	---
Ramps	0.79 Miles	20,300	16,000
Interchange Cross Roads	0.17 Miles	26,400	4,500
Cross Roads and Frontage Roads	1.15 Miles	9,900	11,400
Guard Rail	24,180 L.F.	3.00	72,500
Minor Drainage	7.88 Miles	8,000	63,100
Major Drainage	Lump Sum	---	417,800
Structures	Lump Sum	---	224,700
Lighting and Signing	Lump Sum	---	10,000
Utilities	Lump Sum	---	76,100
Final Surface Treatment	Lump Sum	---	40,200
	CONSTRUCTION COST		$ 6,233,500
Right-of-Way			6,500
Engineering & Contingencies - 15%			935,000
	TOTAL ESTIMATED COST		$ 7,175,000

Stages of Construction

1.	Clearing and Grubbing, Excavation, Drainage, Structures and Utilities	$ 5,209,300
2.	Surfacing, Guard Rail, Signing and Lighting	984,000
3.	Final Surface Treatment	40,200
		$ 6,233,500

TABLE 14

COST ESTIMATE

LINE 1-A - CONTRACT 3

Sta. 846 + 50 to Sta. 1358 + 00
Length 9.68 Miles

Item	Quantity	Unit Price	Cost
Clearing and Grubbing	5 Acres	$ 700	$ 3,500
Type 1 Excavation	1,968,130 C.Y.	0.40	787,300
Type 2 Excavation	--- C.Y.	1.20	---
Surfacing			
4-Lane - 36' Median	-- Miles	99,000	---
4-Lane - 8' Median	-- Miles	113,900	---
4-Lane - 46' Median	6.72 Miles	99,000	665,300
2-Lane - Ult. 4-Lane	2.86 Miles	55,600	159,000
Ramps	1.26 Miles	20,300	25,600
Interchange Cross Roads	0.48 Miles	26,400	12,700
Cross Roads and Frontage Roads	1.56 Miles	9,900	15,500
Guard Rail	31,460 L.F.	3.00	94,400
Minor Drainage	9.68 Miles	8,000	77,400
Major Drainage	Lump Sum	----	59,600
Structures	Lump Sum	----	458,500
Lighting and Signing	Lump Sum	----	65,000
Utilities	Lump Sum	----	8,500
Final Surface Treatment	Lump Sum	----	48,400
	CONSTRUCTION COST		$ 2,480,700
Right-of-Way			151,600
Engineering & Contingencies - 15%			372,100
	TOTAL ESTIMATED COST		$ 3,004,400

Stages of Construction

1. Clearing and Grubbing, Excavation, Drainage, Structures, and Utilities	$ 1,394,800
2. Surfacing, Guard Rail, Signing, and Lighting	1,037,500
3. Final Surface Treatment	48,400
	$ 2,480,700

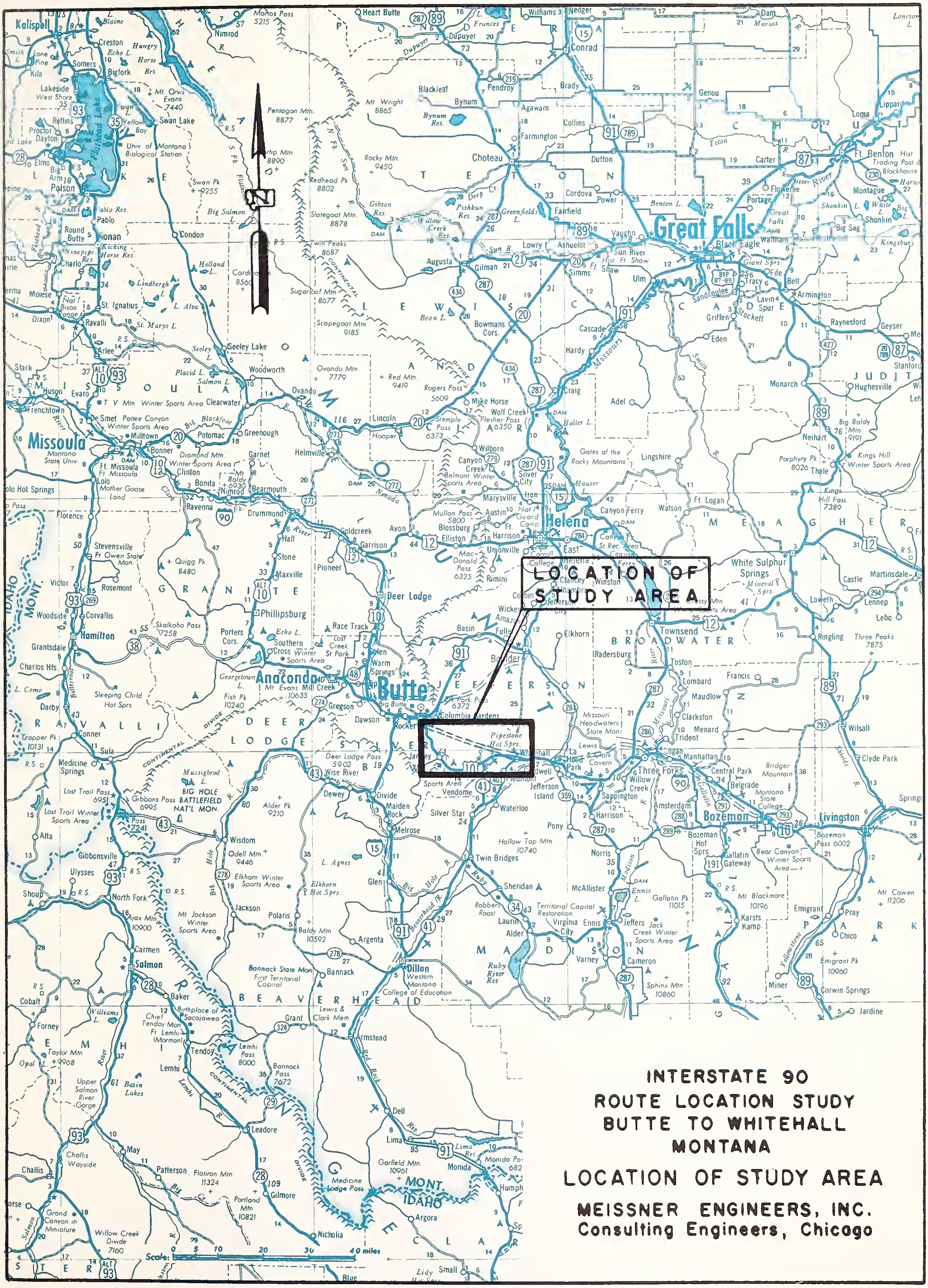
TABLE 15

STAGE CONSTRUCTION RECOMMENDATIONS

LINE 1-A

	DATE OF LETTING		
	Grading and Structures	Surfacing	Final Surface Treatment
Contract 1	July, 1962	March, 1964	April, 1965
Contract 2	July, 1962	March, 1964	April, 1965
Contract 3	Nov., 1962	March, 1964	April, 1965

EXHIBIT I



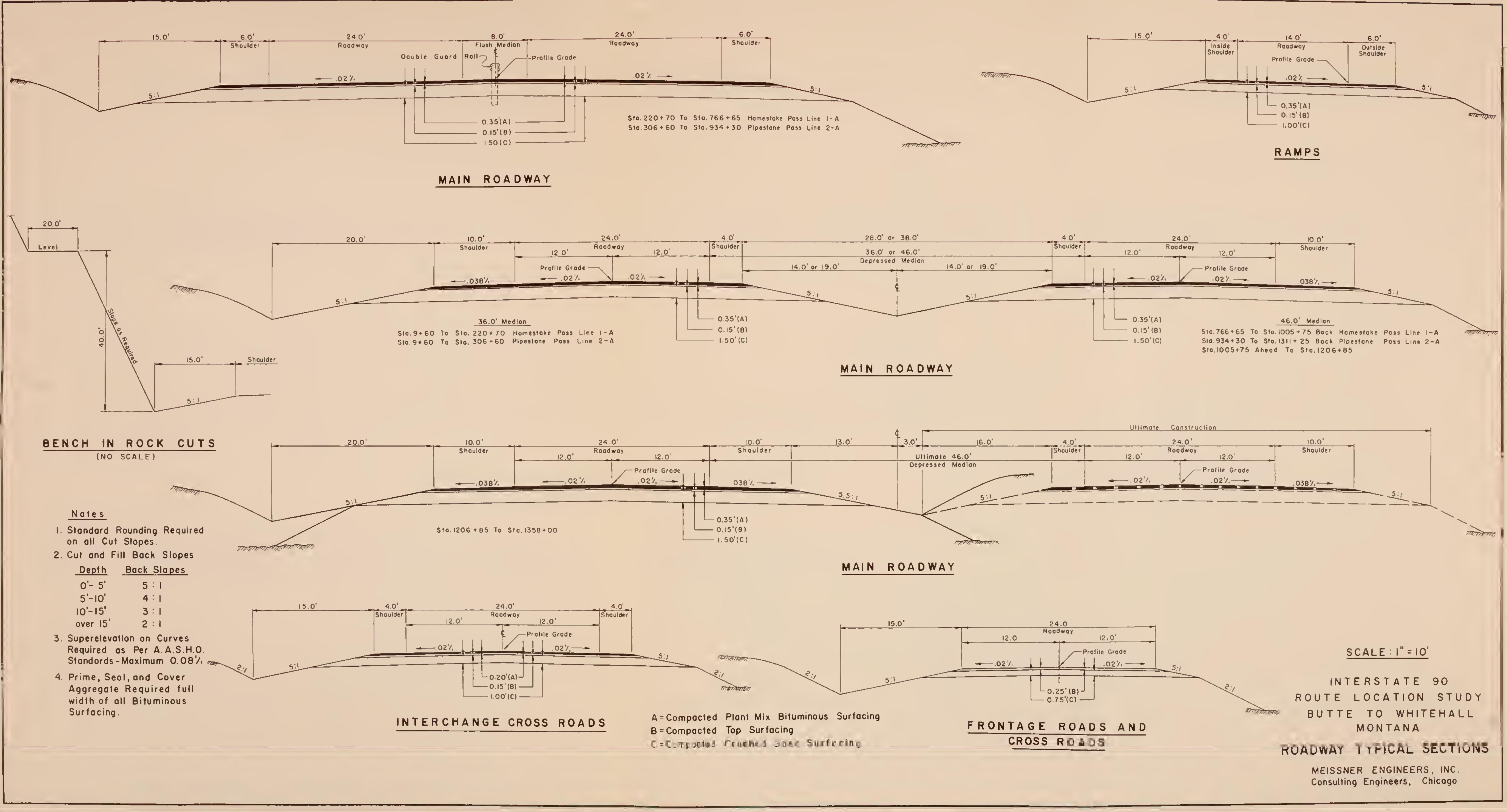
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

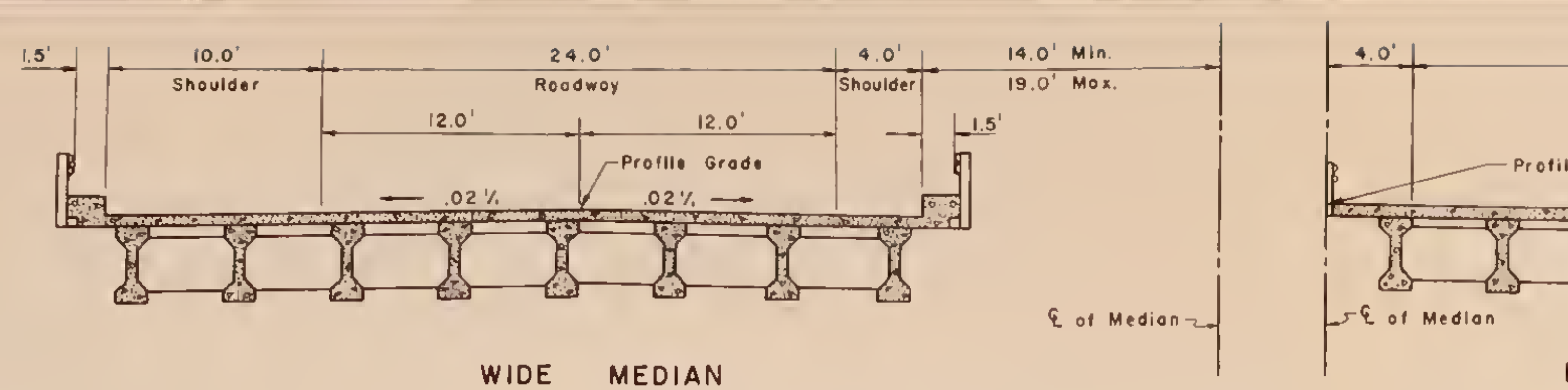
LOCATION OF STUDY AREA

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

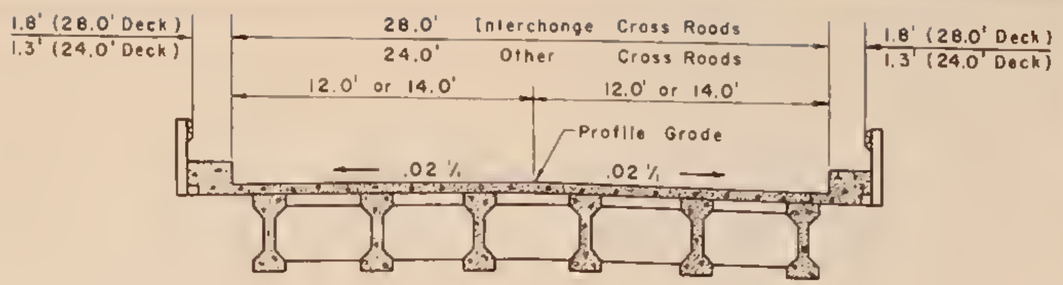
EXHIBIT 2


WALKERVILLE
Route 1
Route 2
Route 3
Route 4
WHITEHALL
LEGEND
Preferred Routes
Alternate Routes
Interchange
SCALE: 1" = 2 MILES
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA
ALTERNATE ROUTES
STUDIED
MEISSNER ENGINEERS, INC.
Consulting Engineers Chicago

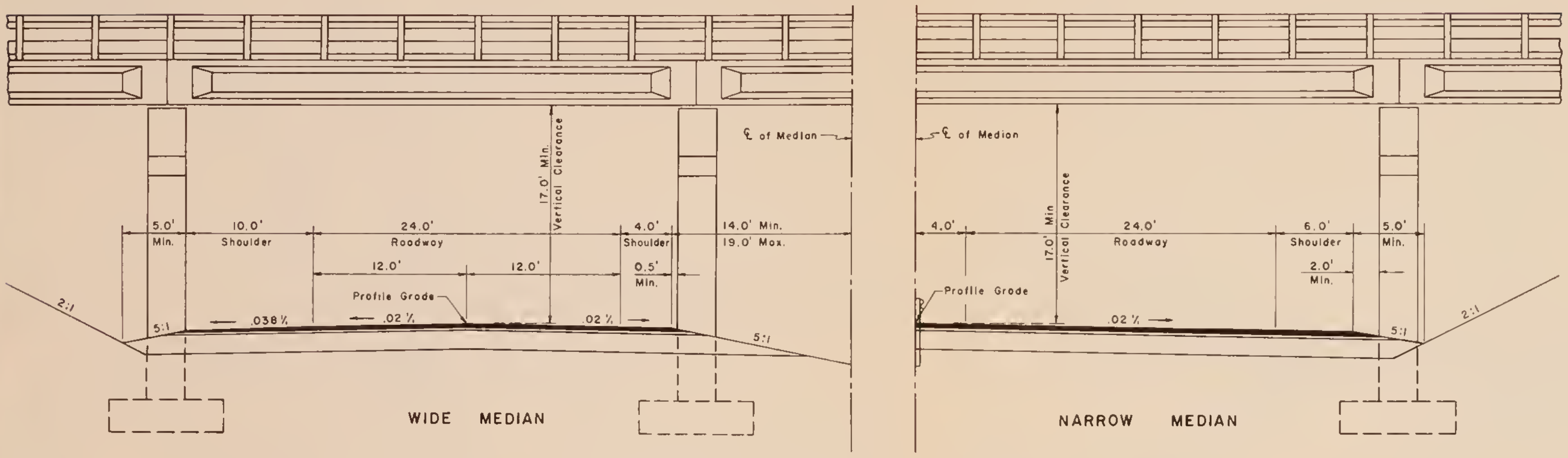

15.0'
6.0' Shoulder
24.0' Roadway
8.0' Flush Median
24.0' Roadway
6.0' Shoulder
Double Guard Rail
Profile Grade
.02% .02%
5:1 5:1
0.35'(A)
0.15'(B)
1.50'(C)
Sta. 220+70 To Sta. 766+65 Homestake Pass Line 1-A
Sta. 306+60 To Sta. 934+30 Pipestone Pass Line 2-A
MAIN ROADWAY
15.0'
4.0' Inside Shoulder
14.0' Roadway
6.0' Outside Shoulder
Profile Grade
.02%
5:1 5:1
0.35'(A)
0.15'(B)
1.00'(C)
RAMPS
20.0'
Level
Slope as Required
40.0'
15.0'
Shoulder
5:1
BENCH IN ROCK CUTS
(NO SCALE)
20.0'
10.0' Shoulder
24.0' Roadway
12.0' 12.0'
4.0' Shoulder
28.0' or 38.0'
36.0' or 46.0' Depressed Median
14.0' or 19.0' 14.0' or 19.0'
4.0' Shoulder
24.0' Roadway
12.0' 12.0'
10.0' Shoulder
Profile Grade
.038% .02% .02% .02% .02% .038%
5:1 5:1 5:1 5:1
0.35'(A)
0.15'(B)
1.50'(C)
36.0' Median
Sta. 9+60 To Sta. 220+70 Homestake Pass Line 1-A
Sta. 9+60 To Sta. 306+60 Pipestone Pass Line 2-A
46.0' Median
Sta. 766+65 To Sta. 1005+75 Back Homestake Pass Line 1-A
Sta. 934+30 To Sta. 1311+25 Back Pipestone Pass Line 2-A
Sta. 1005+75 Ahead To Sta. 1206+85
MAIN ROADWAY
Ultimate Construction
20.0'
10.0' Shoulder
24.0' Roadway
12.0' 12.0'
10.0' Shoulder
13.0'
3.0'
16.0'
Ultimate 46.0' Depressed Median
4.0' Shoulder
24.0' Roadway
12.0' 12.0'
10.0' Shoulder
Profile Grade
.038% .02% .02% .038% .02% .02% .038%
5:1 5.5:1 5:1 5:1
0.35'(A)
0.15'(B)
1.50'(C)
Sta. 1206+85 To Sta. 1358+00
MAIN ROADWAY
Notes
1. Standard Rounding Required on all Cut Slopes.
2. Cut and Fill Back Slopes
Depth Back Slopes
0'-5' 5:1
5'-10' 4:1
10'-15' 3:1
over 15' 2:1
3. Superelevation on Curves Required as Per A.A.S.H.O. Standards - Maximum 0.08%
4. Prime, Seal, and Cover Aggregate Required full width of all Bituminous Surfacing.
15.0'
4.0' Shoulder
24.0' Roadway
12.0' 12.0'
4.0' Shoulder
Profile Grade
.02% .02%
2:1 5:1 5:1 2:1
0.20'(A)
0.15'(B)
1.00'(C)
INTERCHANGE CROSS ROADS
A = Compacted Plant Mix Bituminous Surfacing
B = Compacted Top Surfacing
C = Compacted Crushed Base Surfacing
15.0'
24.0 Roadway
12.0 12.0'
Profile Grade
.02% .02%
2:1 5:1 5:1 2:1
0.25'(B)
0.75'(C)
FRONTAGE ROADS AND CROSS ROADS
SCALE: 1" = 10'
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA
ROADWAY TYPICAL SECTIONS
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago



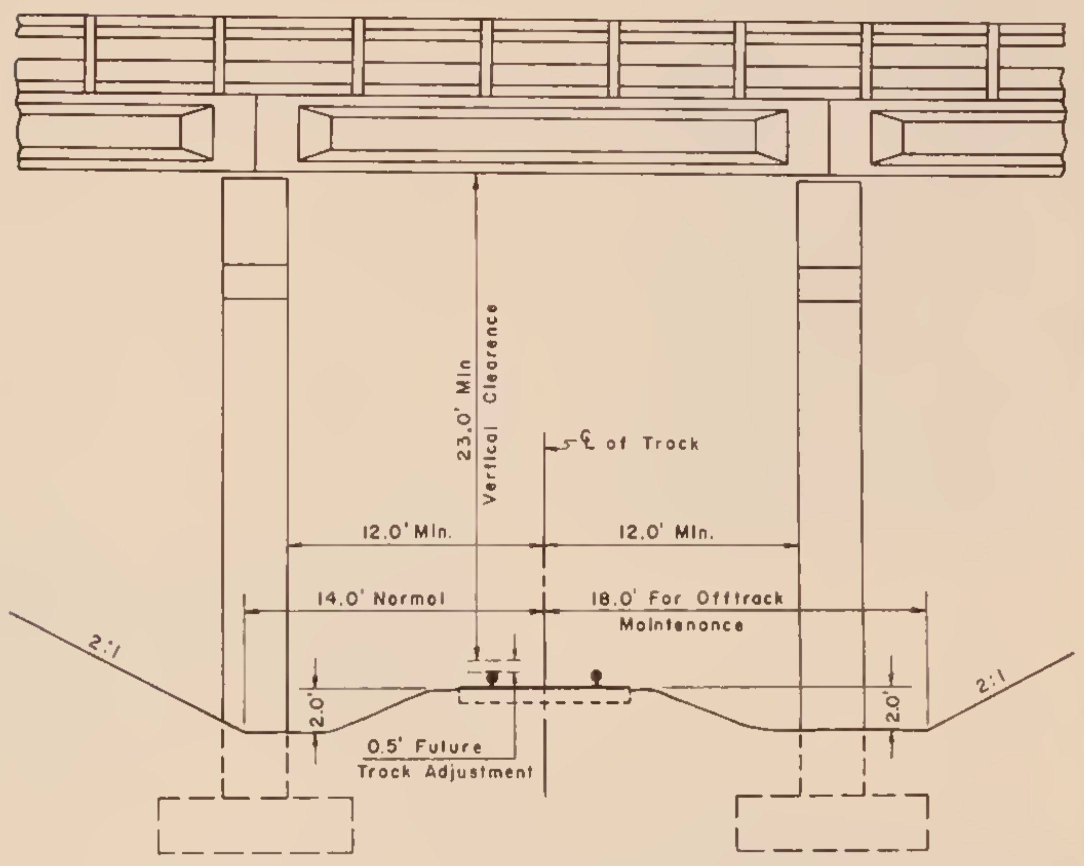
HALF SECTIONS — FREEWAY OVERPASS



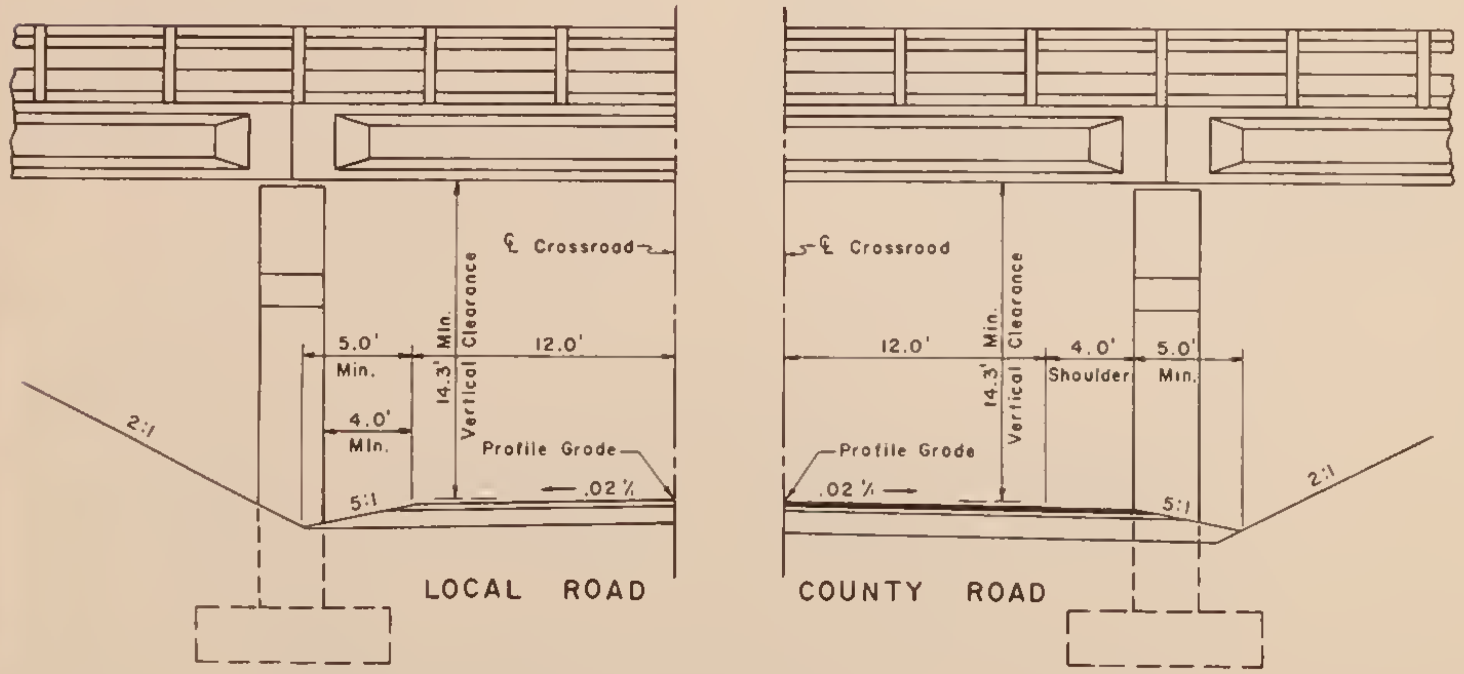
TYPICAL SECTION — CROSSROAD OVERPASS



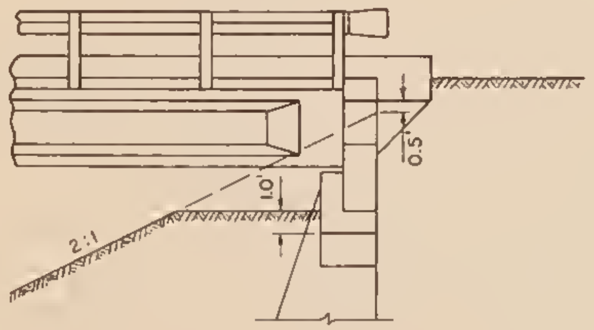
HALF SECTIONS — FREEWAY UNDERPASS



TYPICAL SECTION – NORTHERN PACIFIC RAILROAD UNDERPASS



HALF SECTIONS — CROSSROAD UNDERPASS



TYPICAL ABUTMENT DETAIL

Notes

1. For Freeway Structures 150' or less, use Shoulders as shown.
   For Freeway Structures over 150' long, use 2' Shoulders left and right.
2. For Freeway Structures 150' or less, use Curb widths as shown.
   For Freeway Structures over 150' long, use Curb 1.8' wide.
3. The Bridge Beam depths, spacings, and types shown are for illustrative purposes only.

SCALE: 1" = 10'

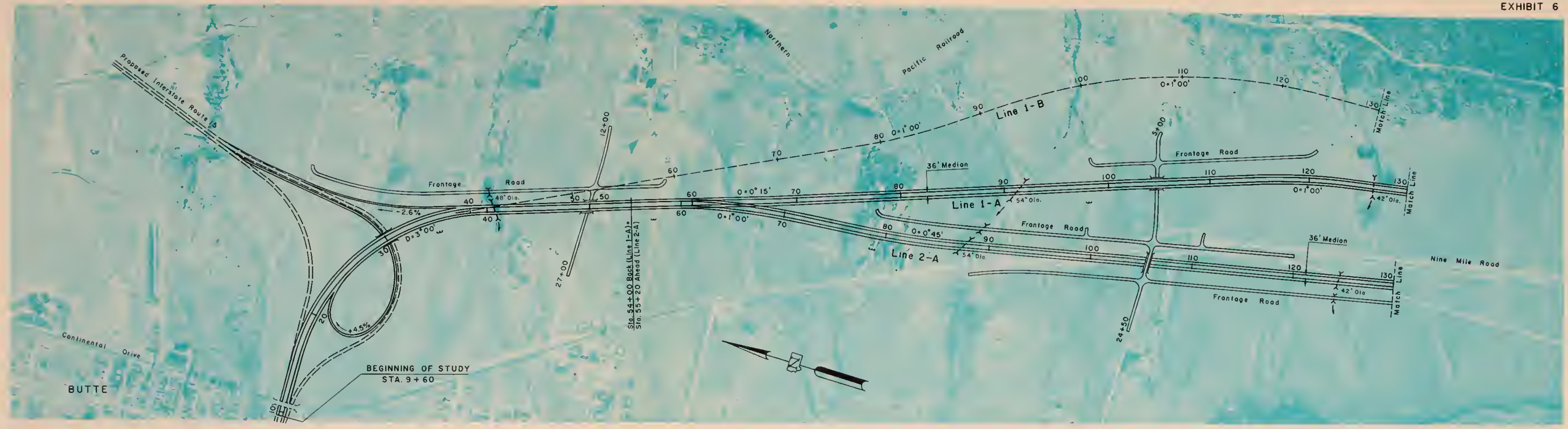
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

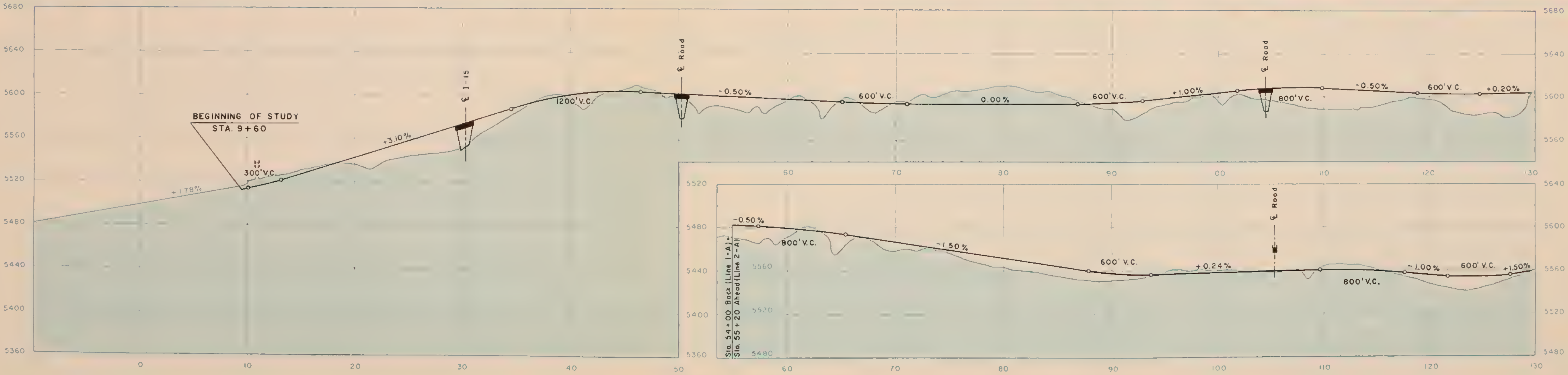
BRIDGE TYPICAL SECTIONS

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago


WALKERVILLE
BUTTE
WHITEHALL
Route 1
Route 2
Exhibit 6
Exhibit 7
Exhibit 8
Exhibit 9
Exhibit 10
Exhibit 11
Exhibit 12
Exhibit 13
Exhibit 14
Exhibit 15
Exhibit 16
Exhibit 17
Exhibit 18
Exhibit 19
Exhibit 20
Exhibit 21
Exhibit 22
Exhibit 23
DEER LODGE
NATIONAL
FOREST
BASE LINE
SCALE: 1" = 2 MILES
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA
KEY MAP
TO PLAN & PROFILE SHEETS
MEISSNER ENGINEERS, INC.
Consulting Engineers Chicago

EXHIBIT 6





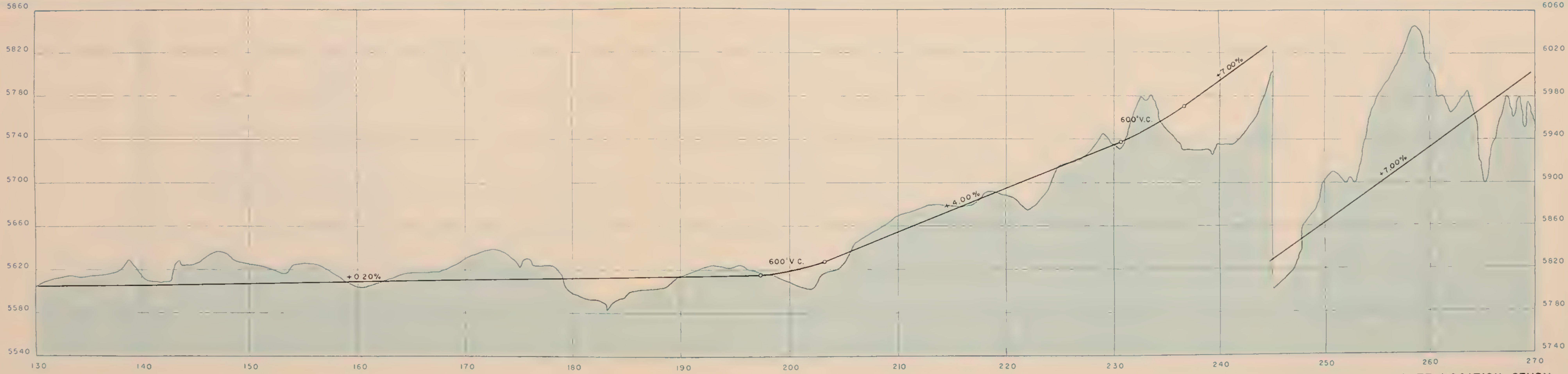
SCALE

HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 9+60 TO STA. 130+00



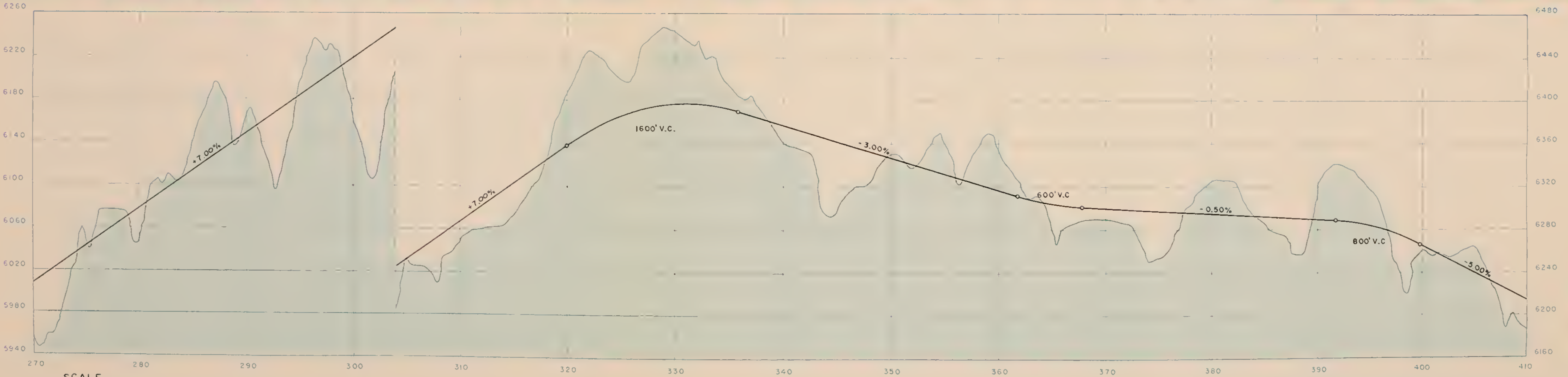
SCALE

HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 130+00 TO STA. 270+00



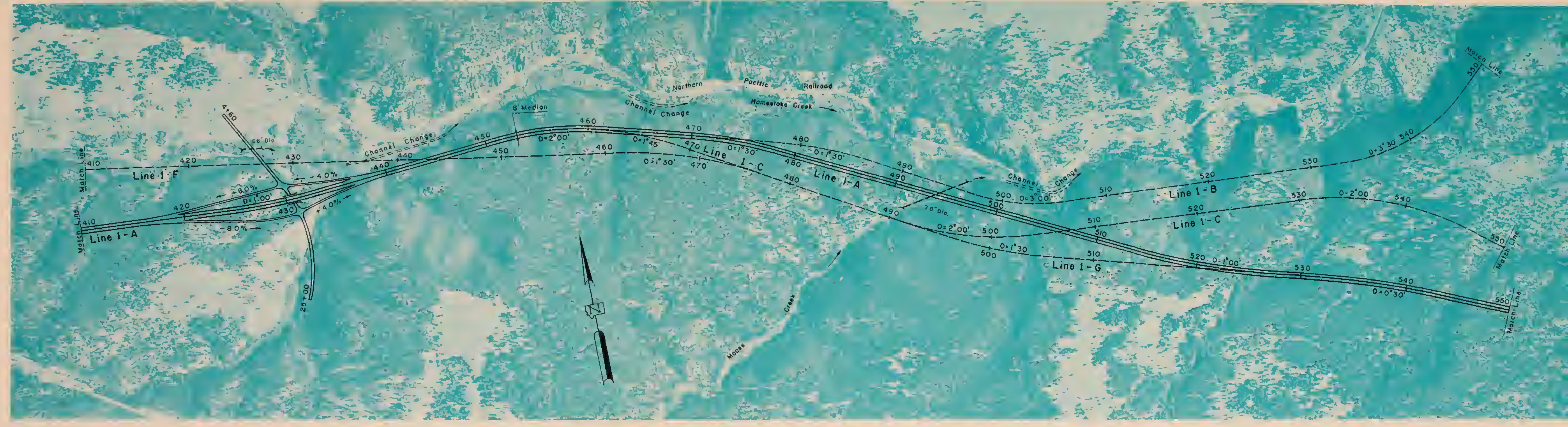
SCALE

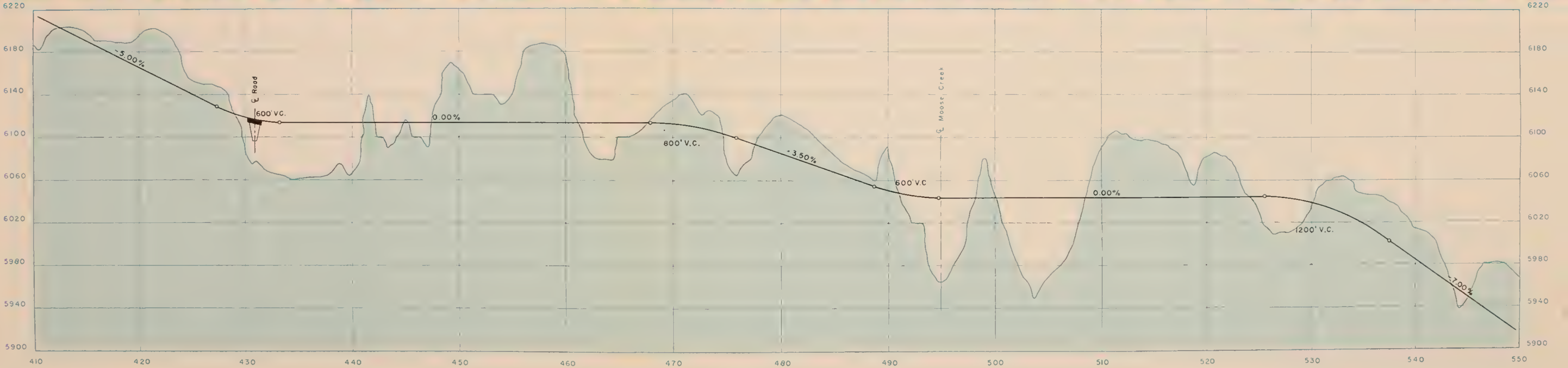
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 270+00 TO STA. 410+00





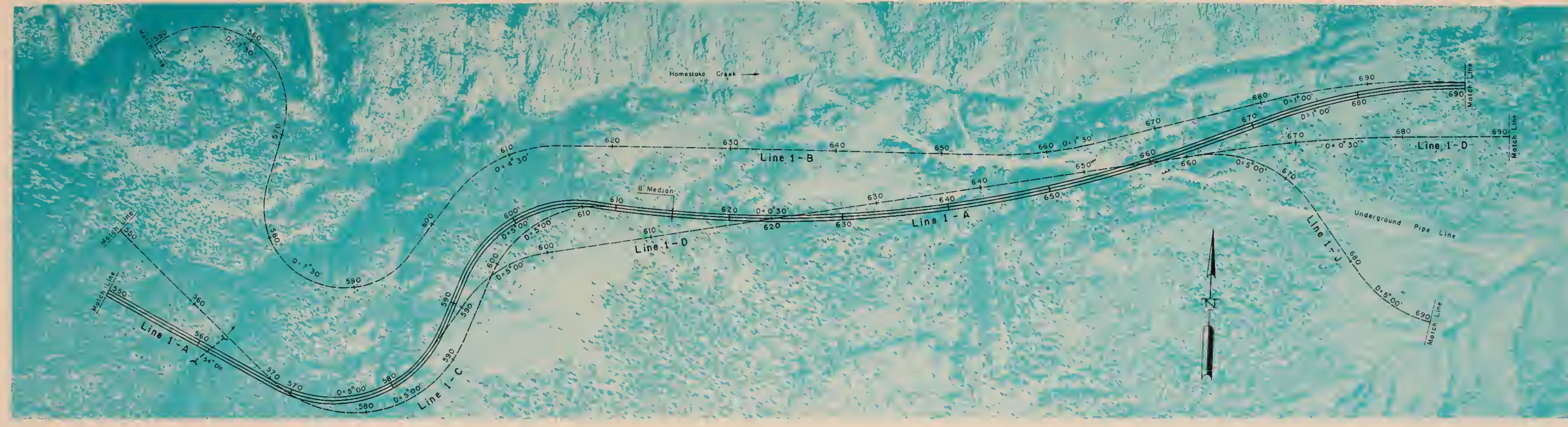
SCALE

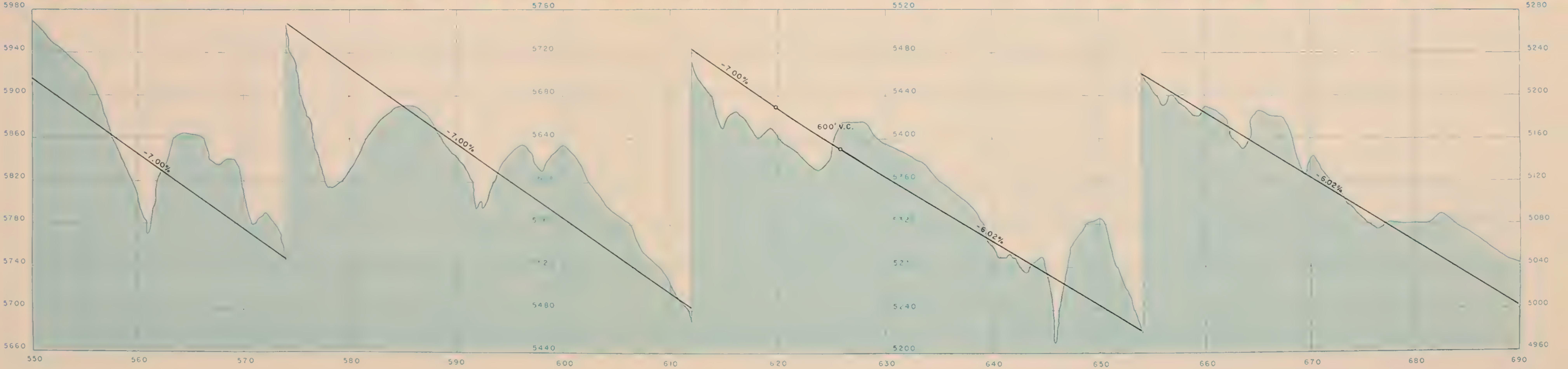
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 410+00 TO STA. 550+00





SCALE

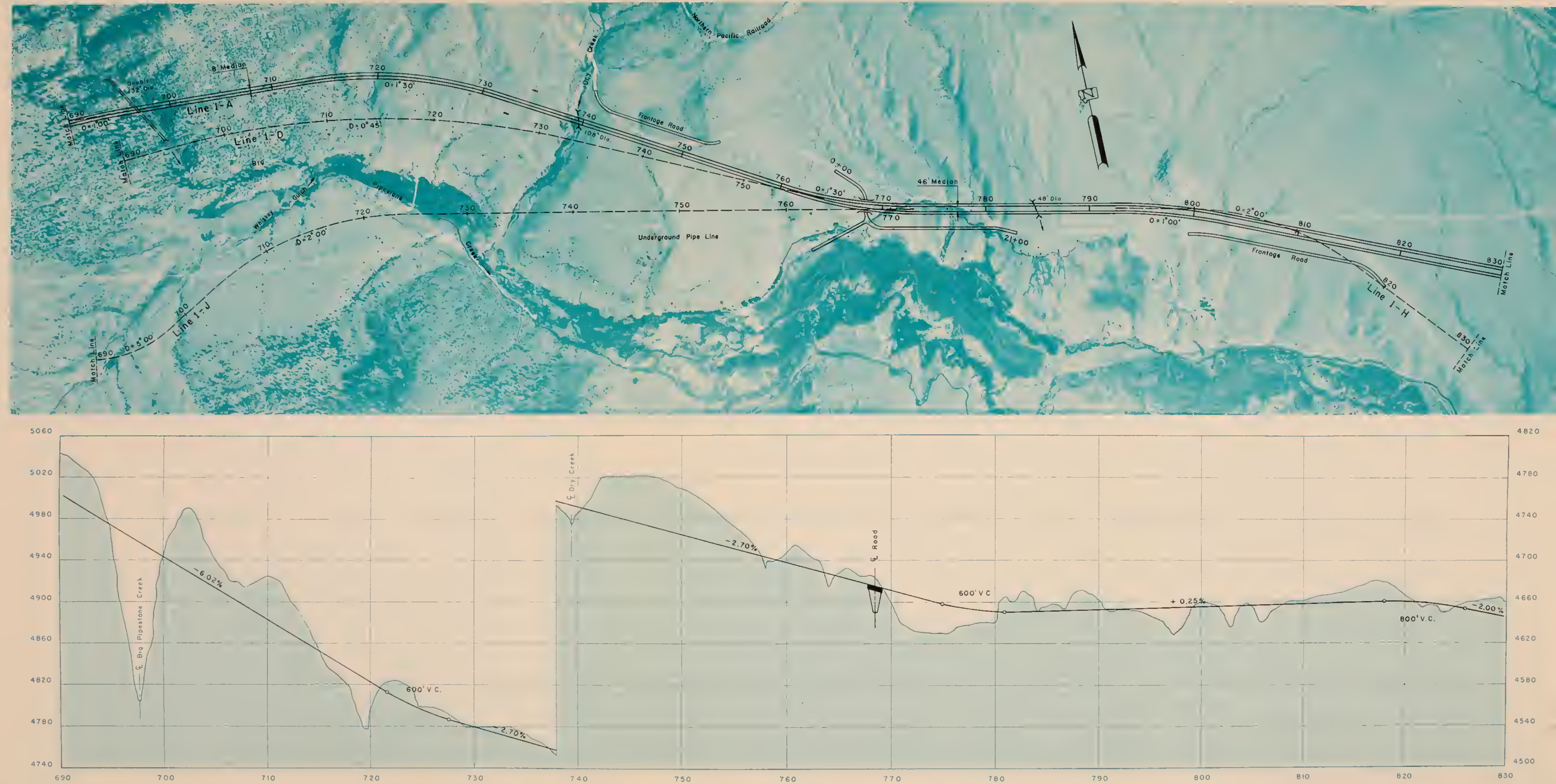
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 550+00 TO STA. 690+00

EXHIBIT 11



SCALE

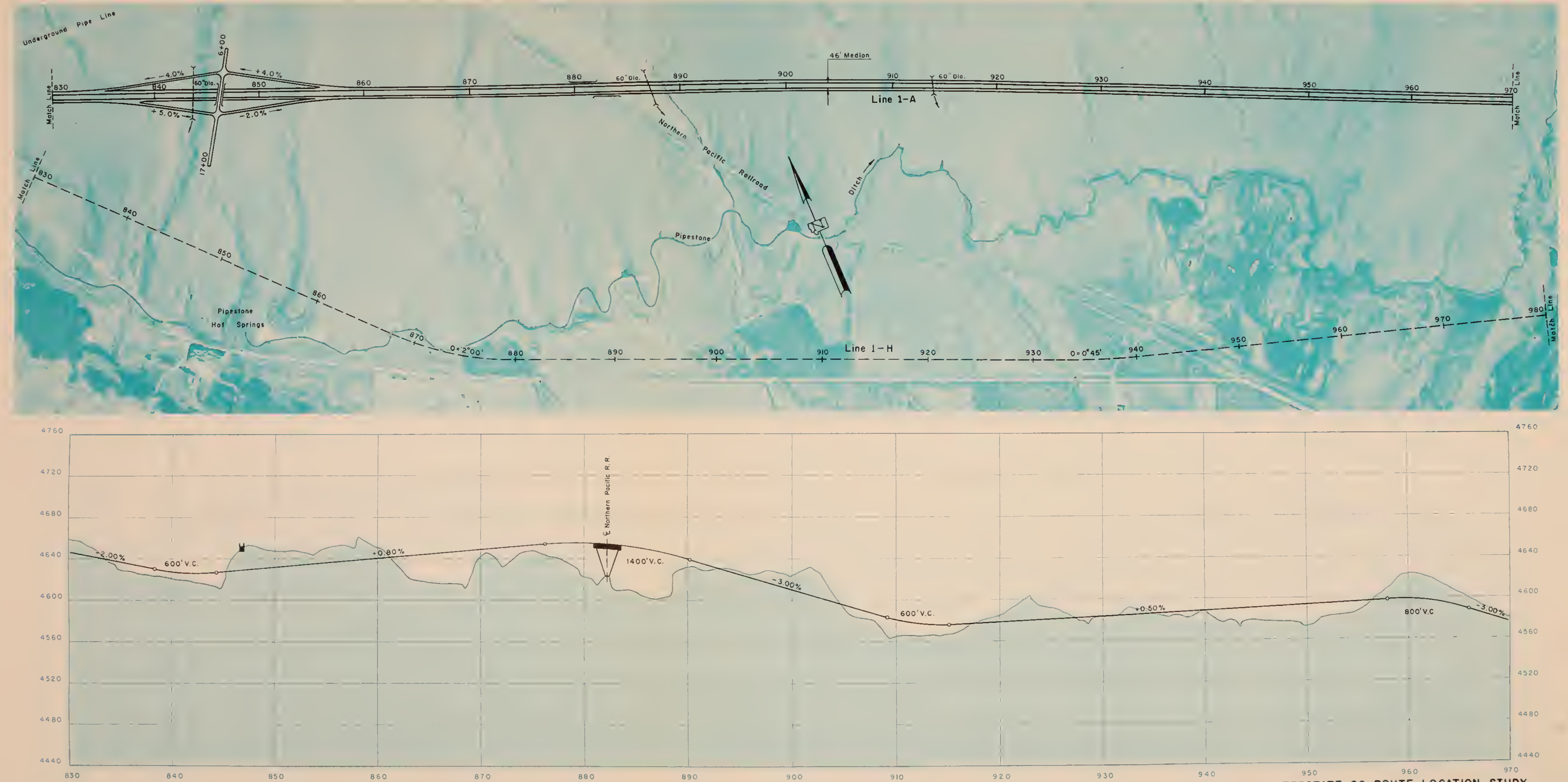
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 690+00 TO STA. 830+00

EXHIBIT 12



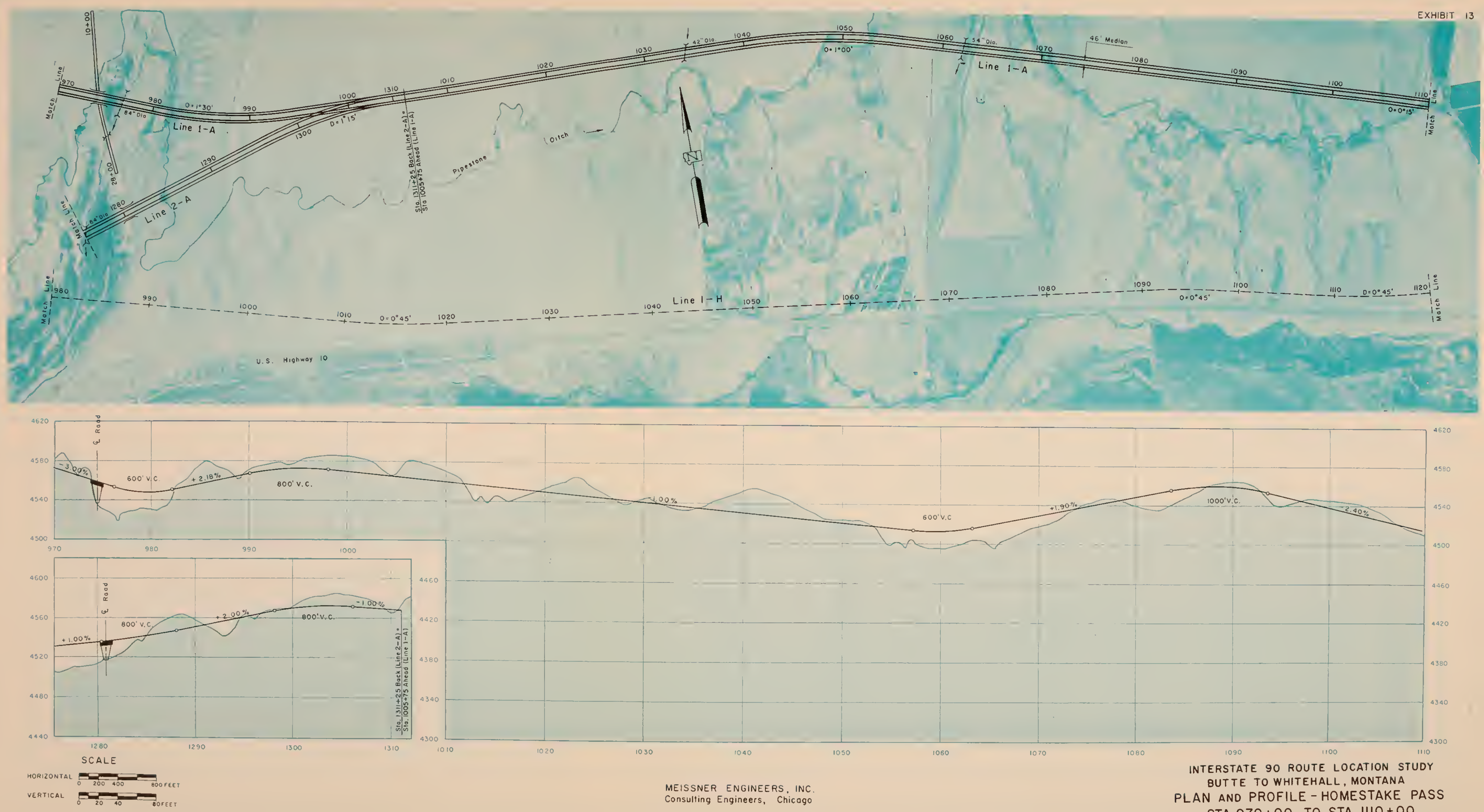
SCALE

HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

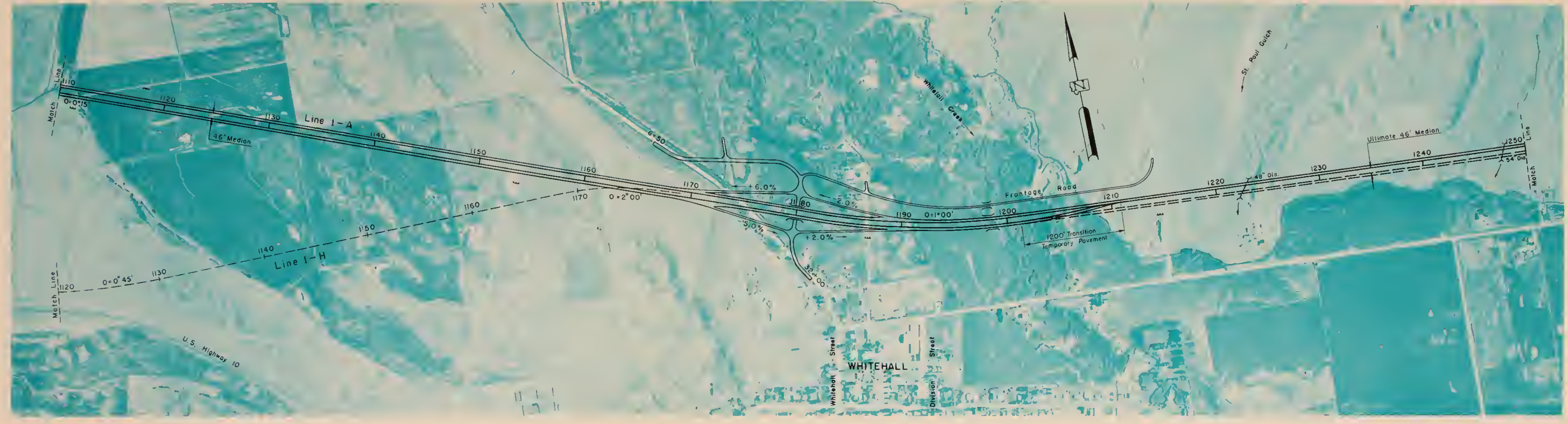
MEISSNER ENGINEERS, INC
Consulting Engineers, Chicago

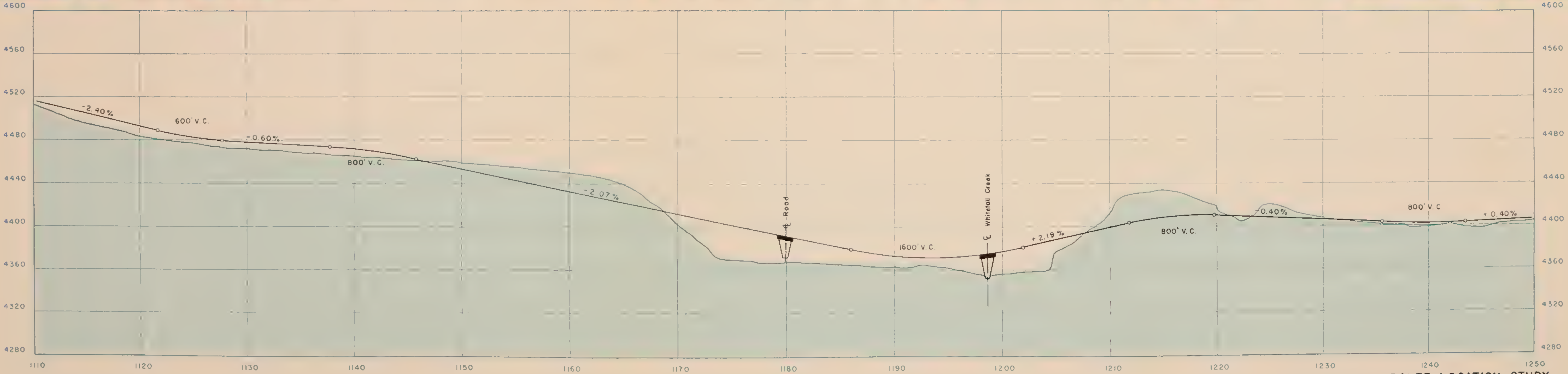
INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 830+00 TO STA. 970+00



MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 970+00 TO STA. 1110+00





SCALE

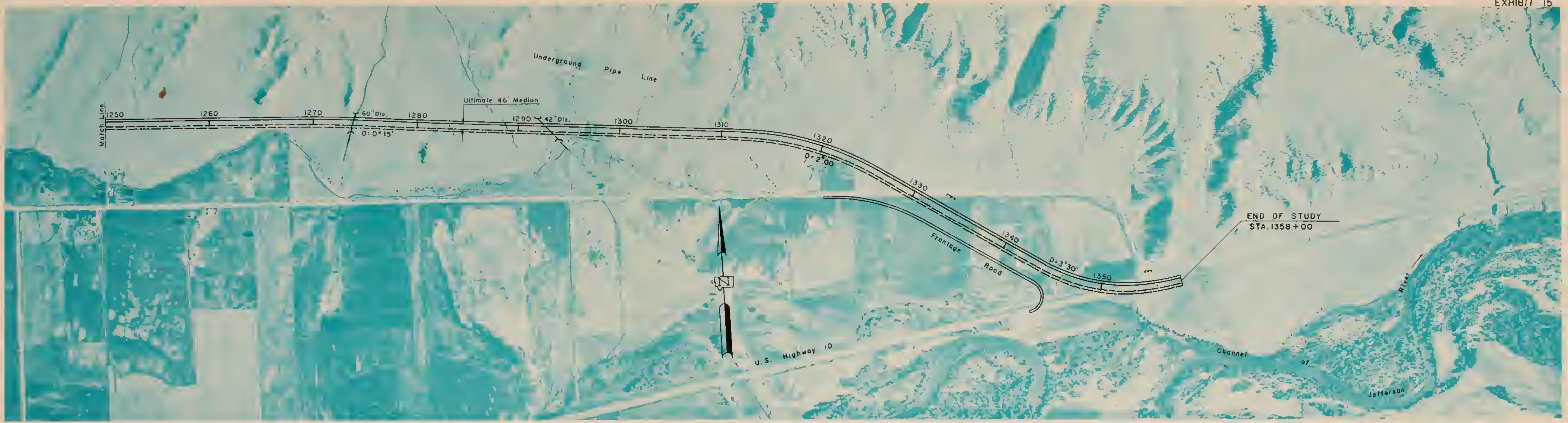
HORIZONTAL 0 200 400 600 FEET

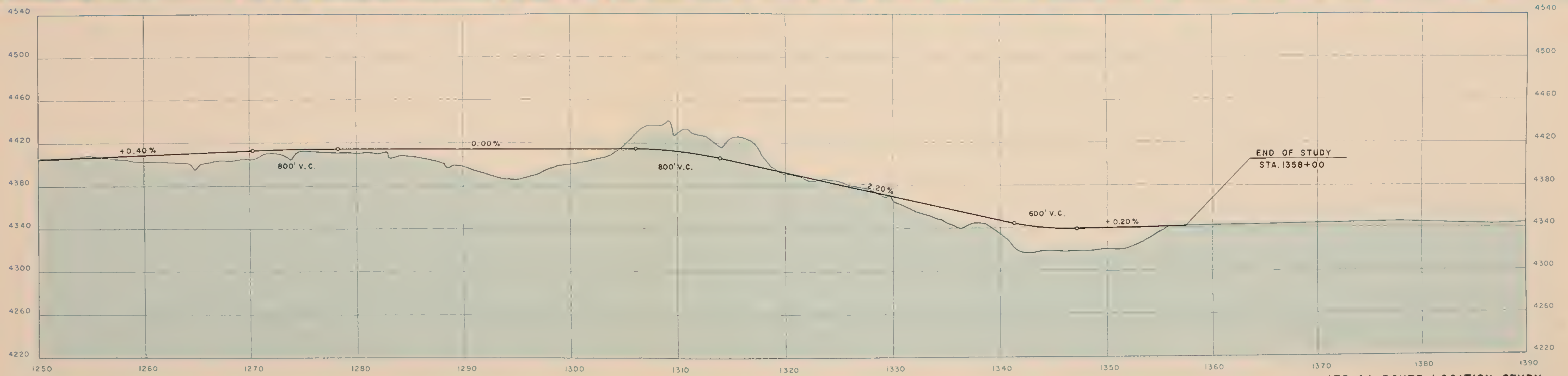
VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 1110+00 TO STA. 1250+00

EXHIBIT 15





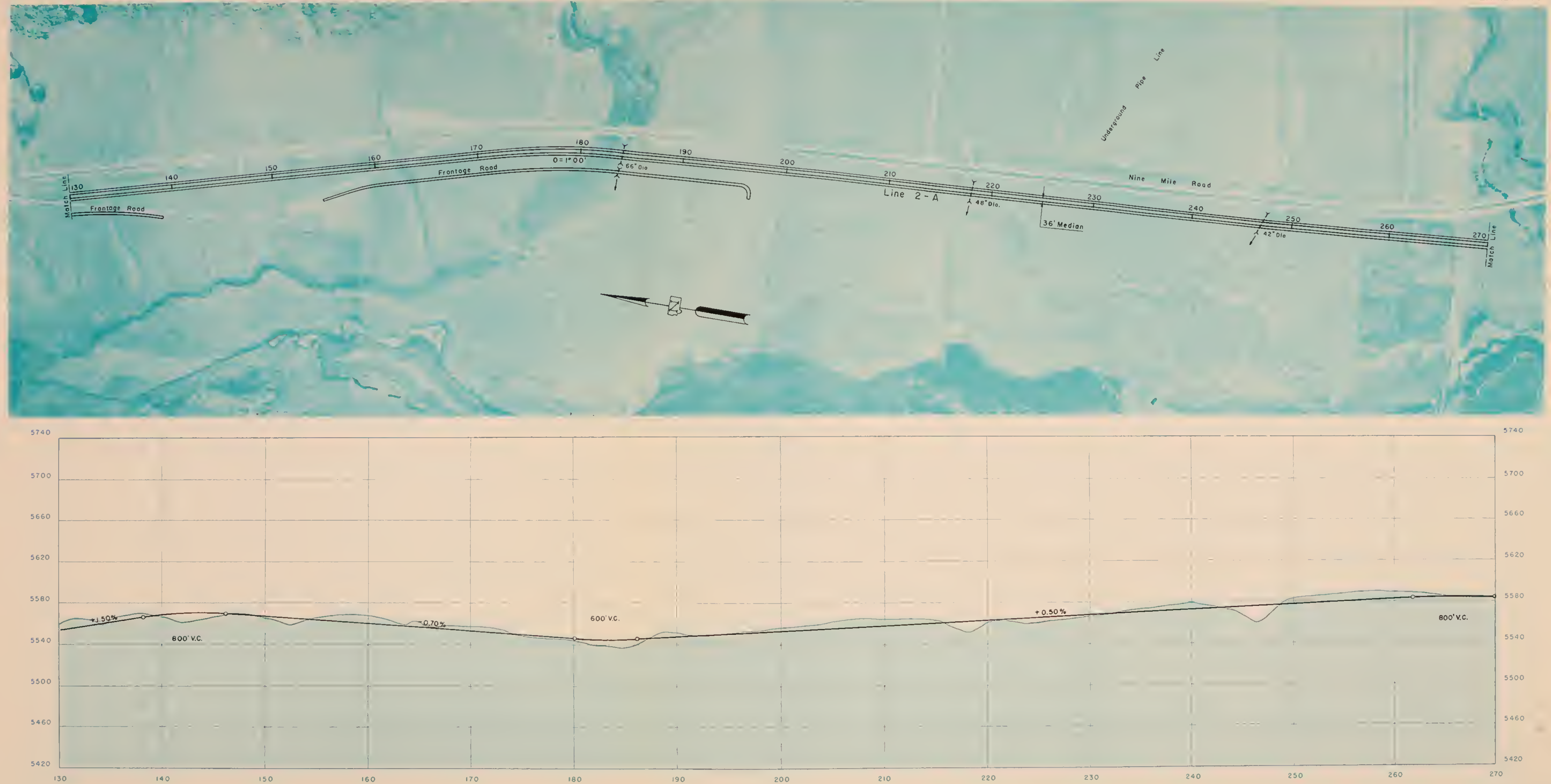
SCALE

HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - HOMESTAKE PASS
STA. 1250+00 TO STA. 1358+00



SCALE

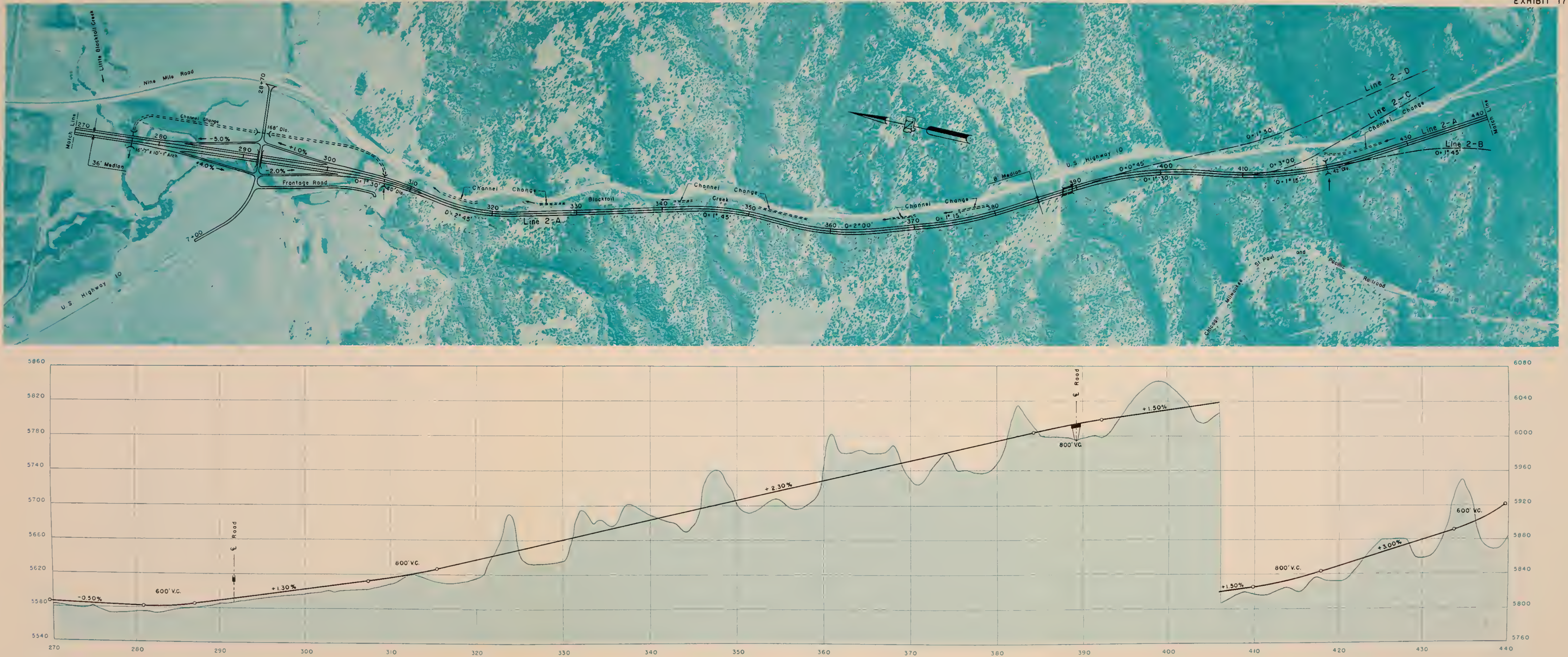
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 130+00 TO STA. 270+00

EXHIBIT 17



SCALE

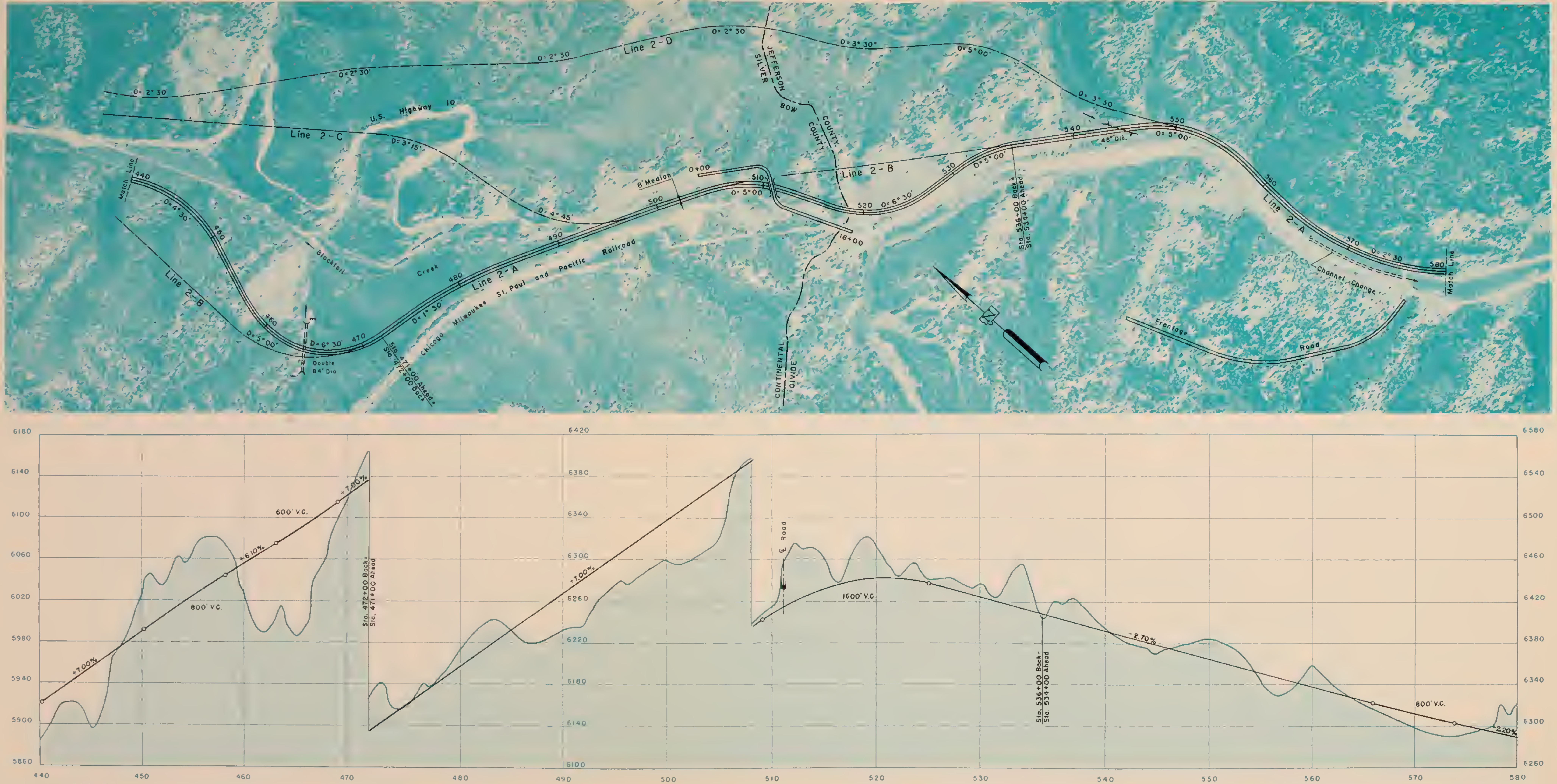
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 270+00 TO STA. 440+00

EXHIBIT 18



SCALE

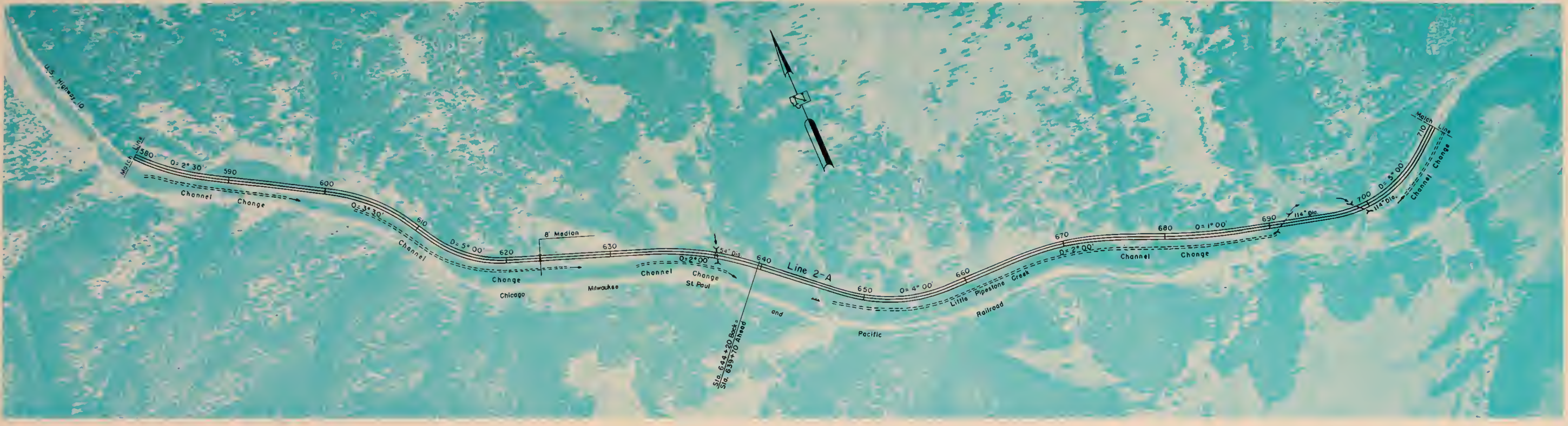
HORIZONTAL 0 200 400 600 FEET

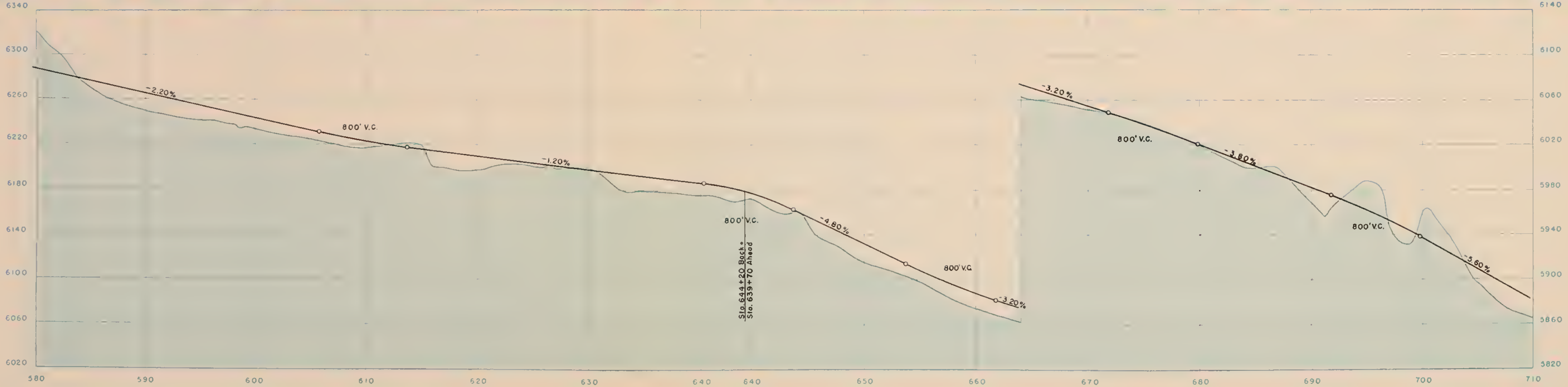
VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 440+00 TO STA. 580+00

EXHIBIT 19





SCALE

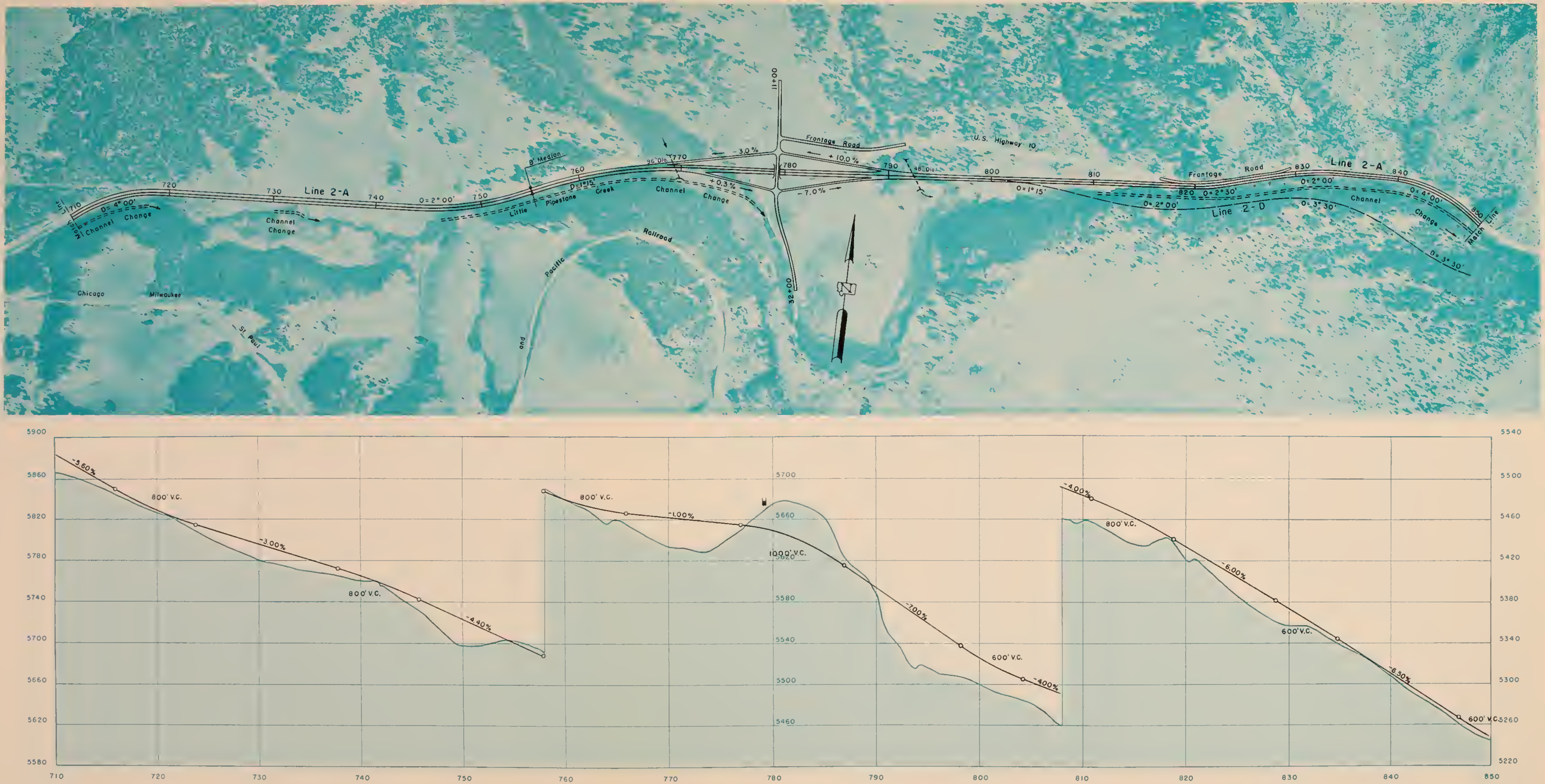
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 580+00 TO STA. 710+00

EXHIBIT 20



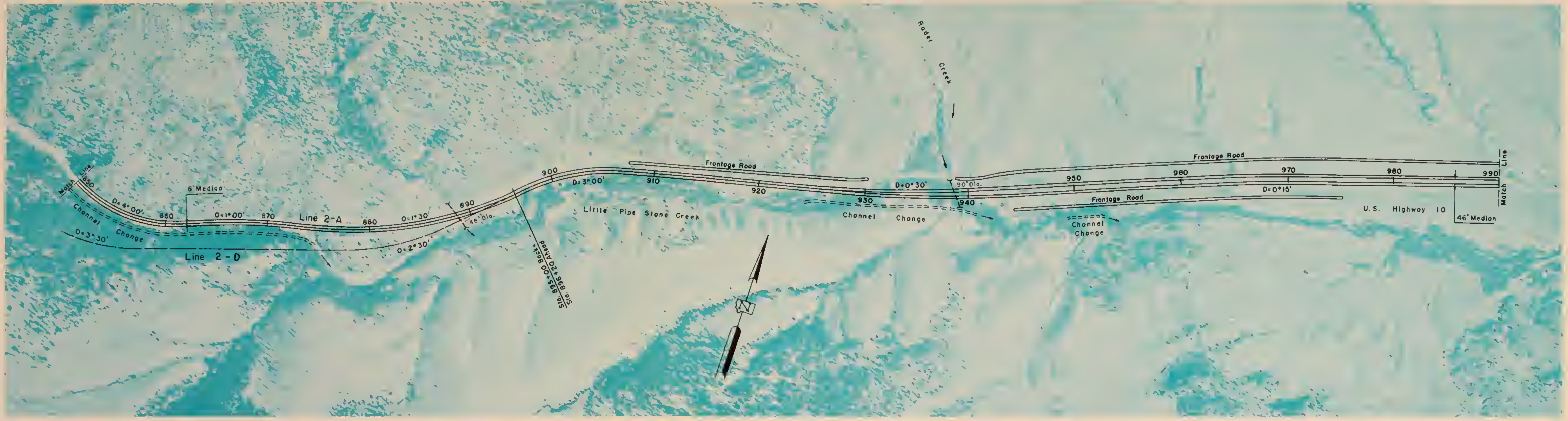
SCALE

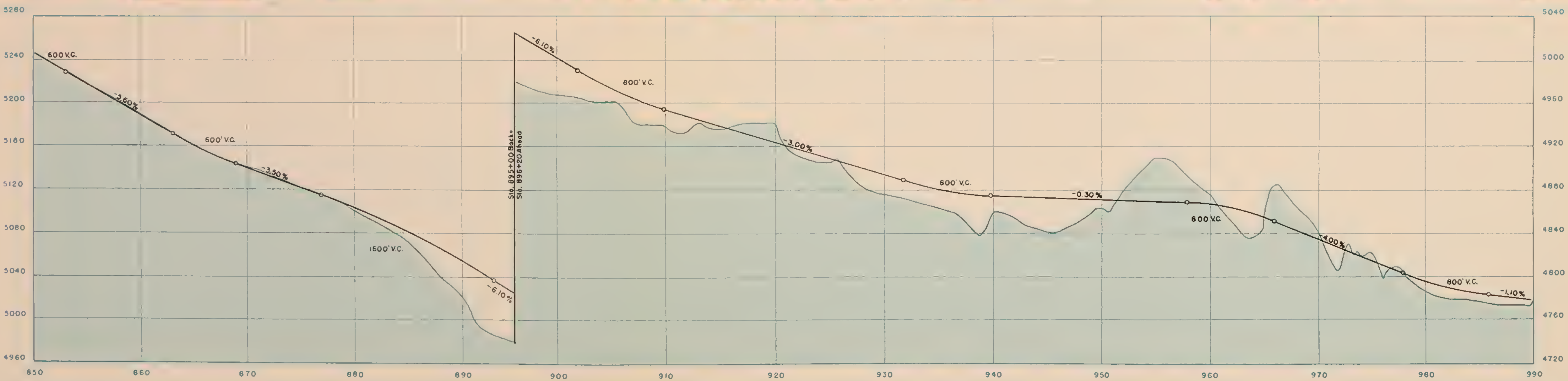
HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 710+00 TO STA. 850+00





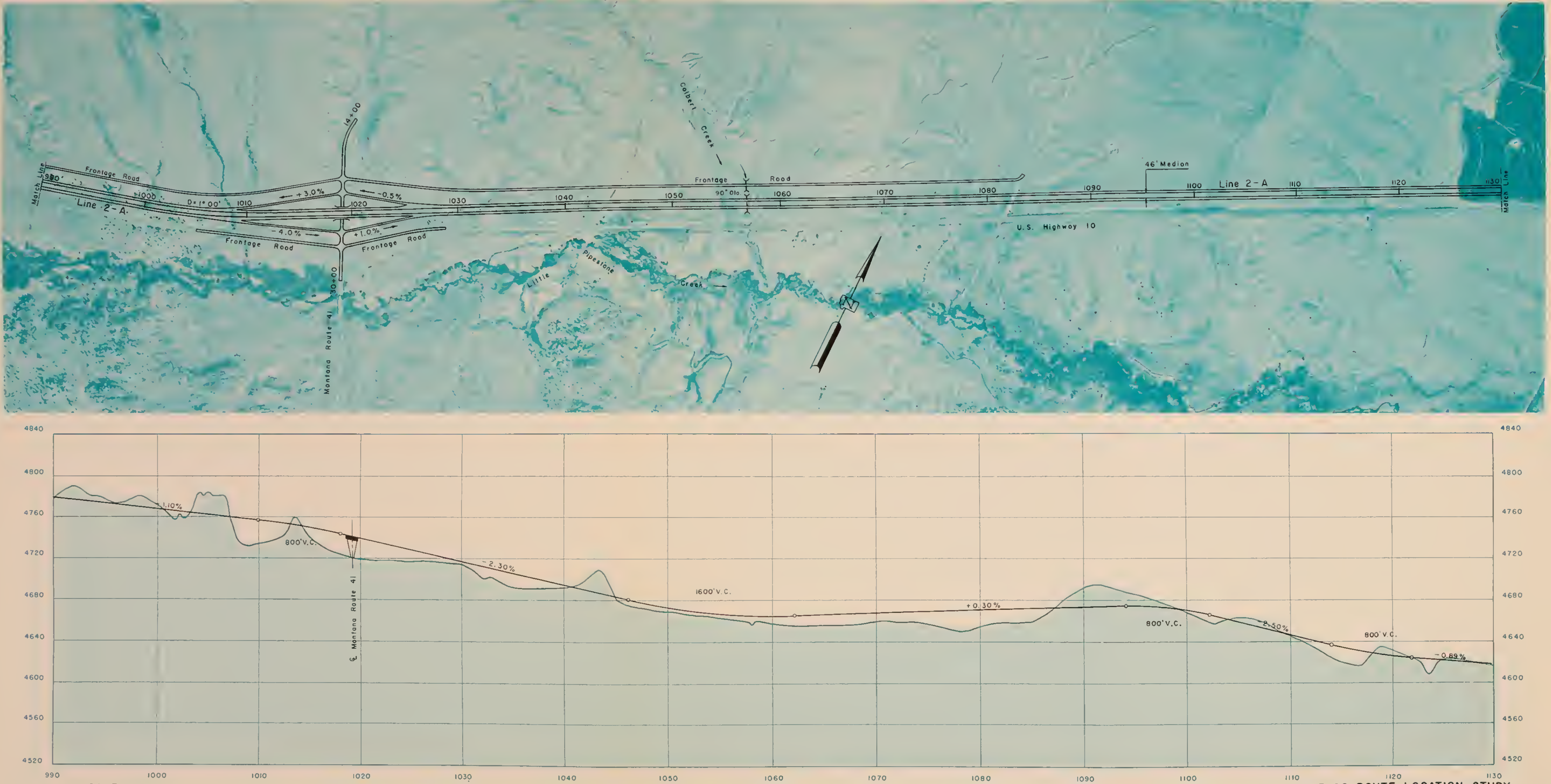
SCALE

HORIZONTAL 0 200 400 800 FEET

VERTICAL 0 20 40 60 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 850+00 TO STA. 990+00



SCALE

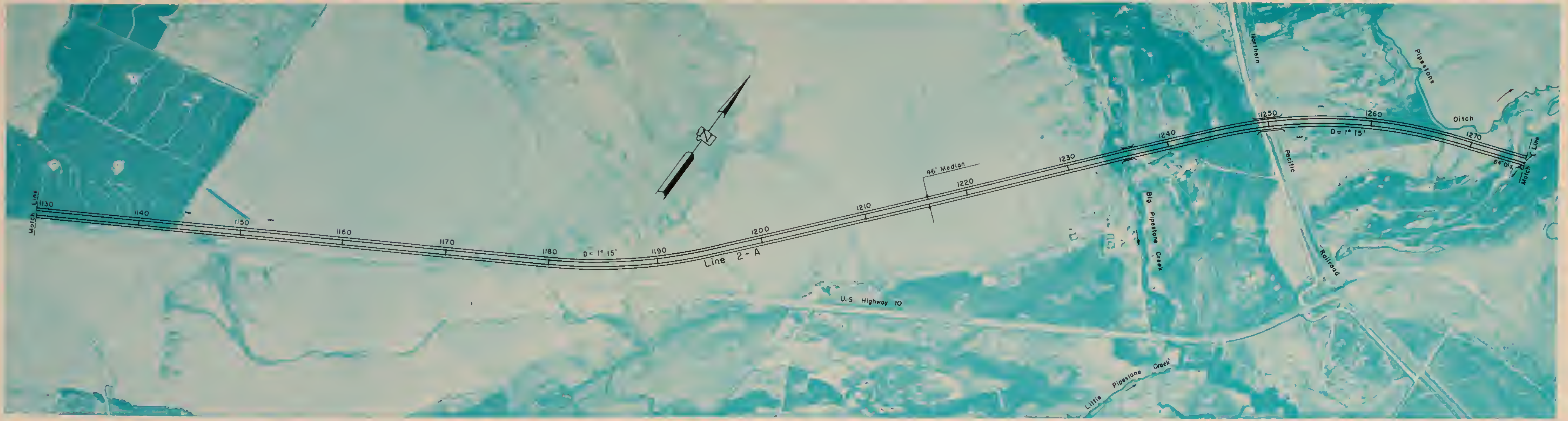
HORIZONTAL 0 200 400 800 FEET

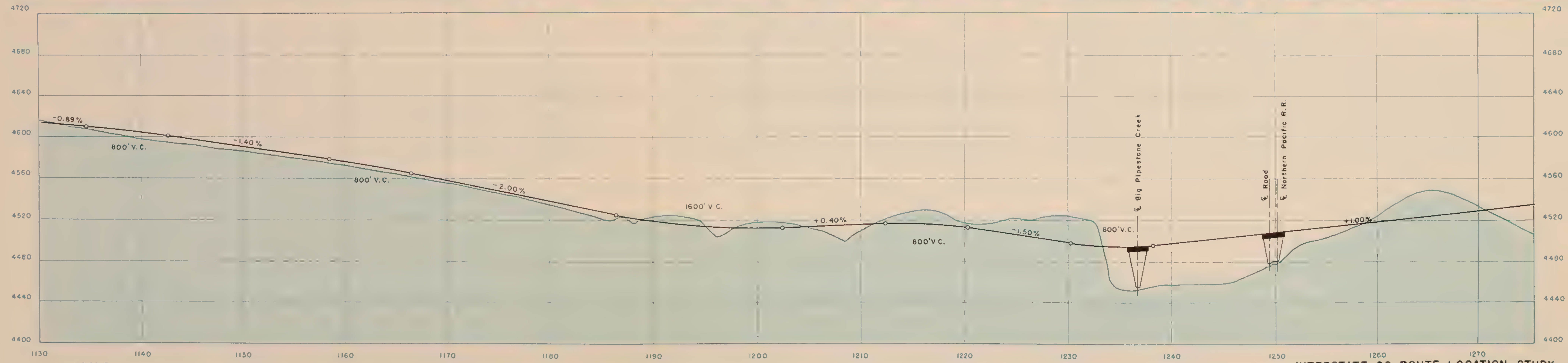
VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 990+00 TO STA. 1130+00

EXHIBIT 23





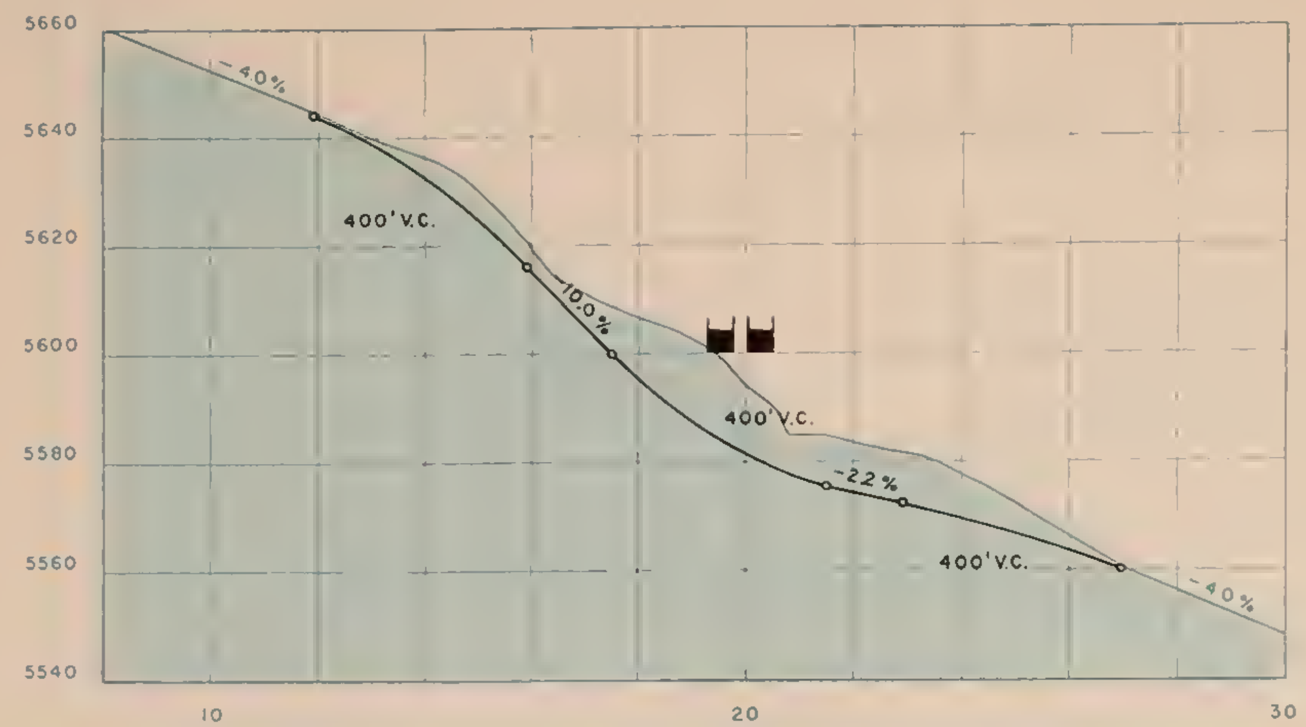
SCALE

HORIZONTAL 0 200 400 800 FEET

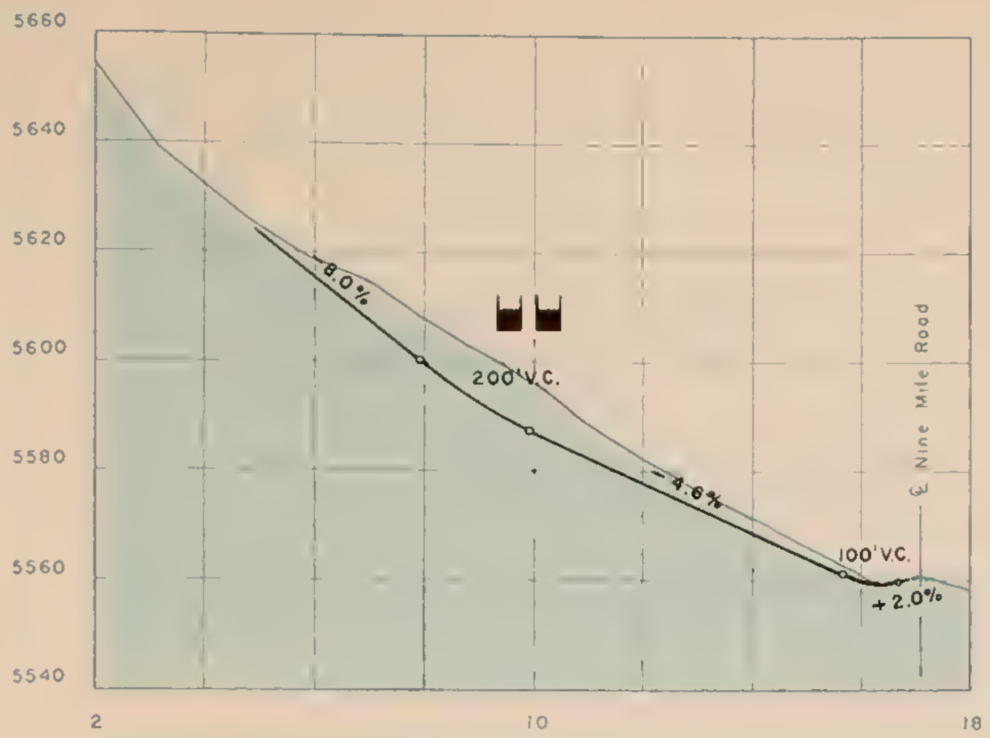
VERTICAL 0 20 40 80 FEET

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

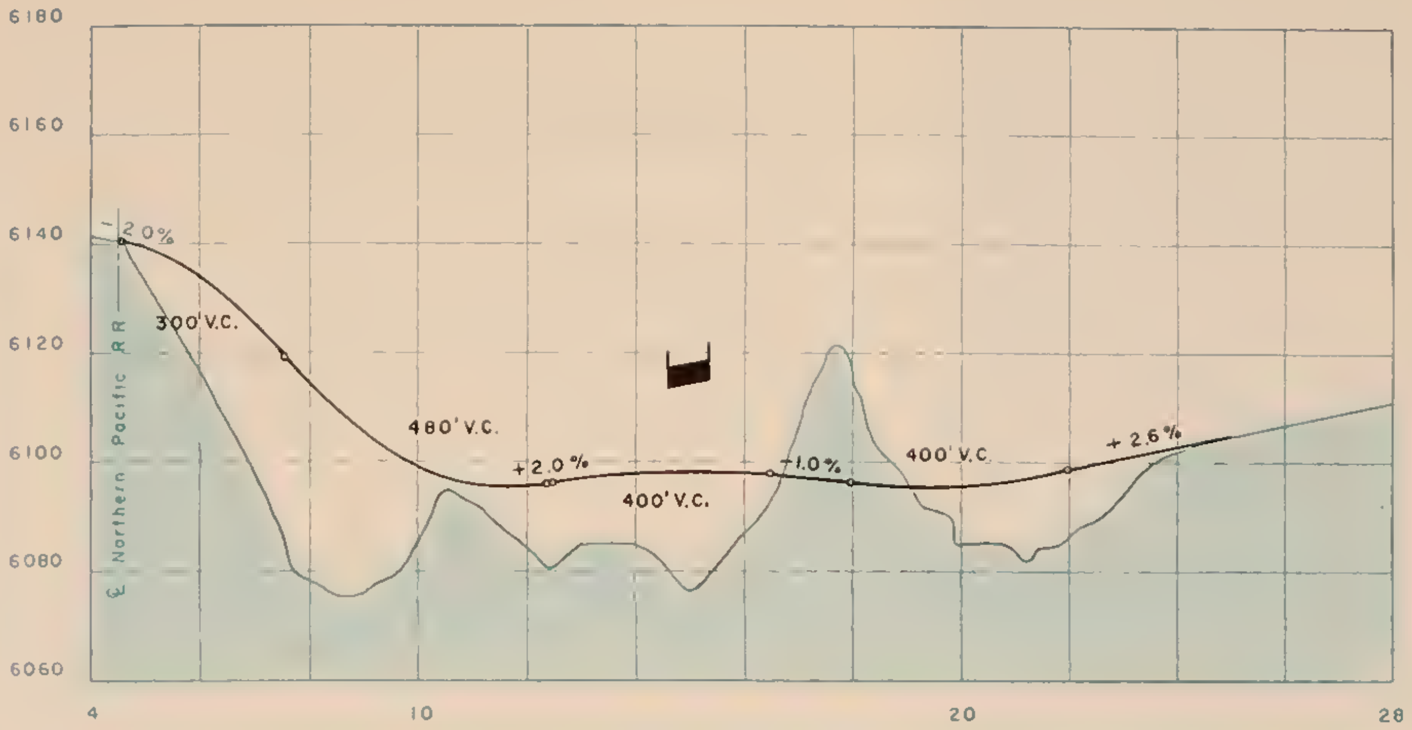
INTERSTATE 90 ROUTE LOCATION STUDY
BUTTE TO WHITEHALL, MONTANA
PLAN AND PROFILE - PIPESTONE PASS
STA. 1130+00 TO STA. 1275+50



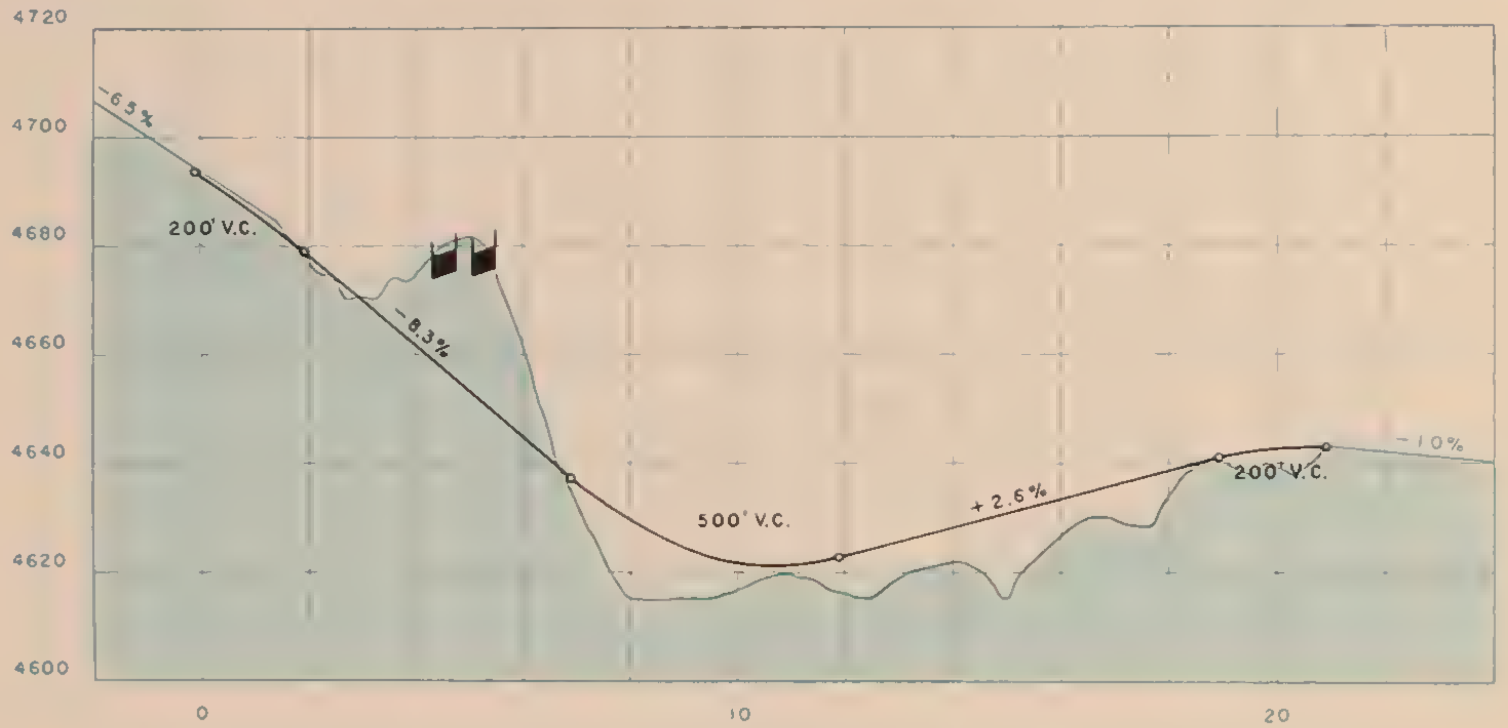
I-90 STA. 50+25



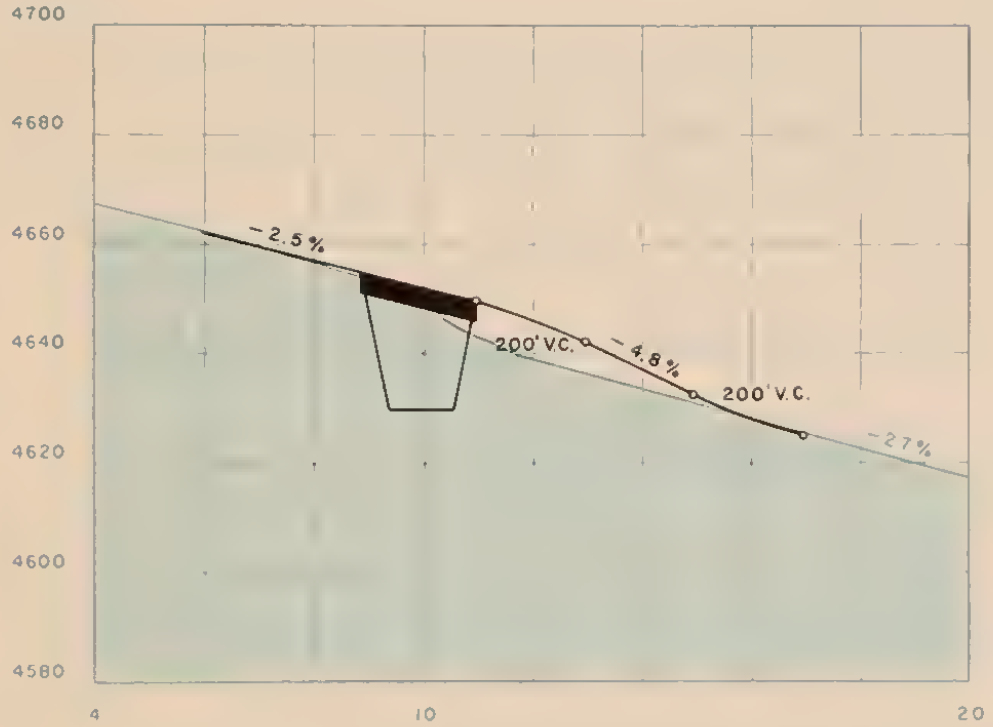
I-90 STA. 104+75



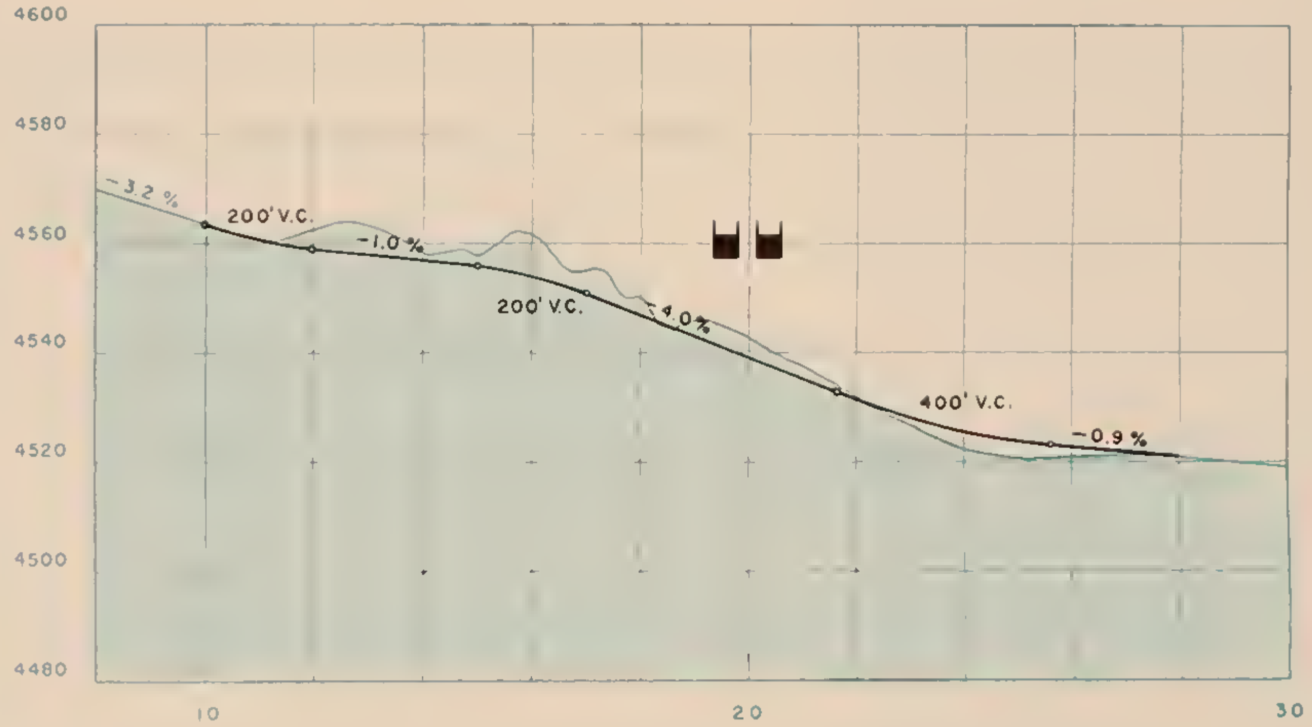
I-90 STA. 430+60



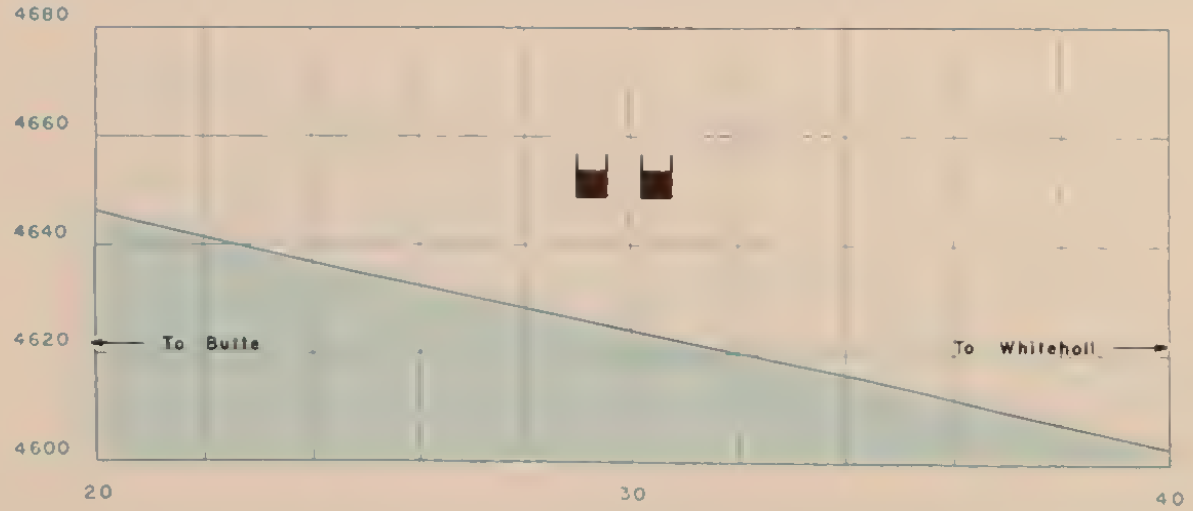
I-90 STA. 768+50



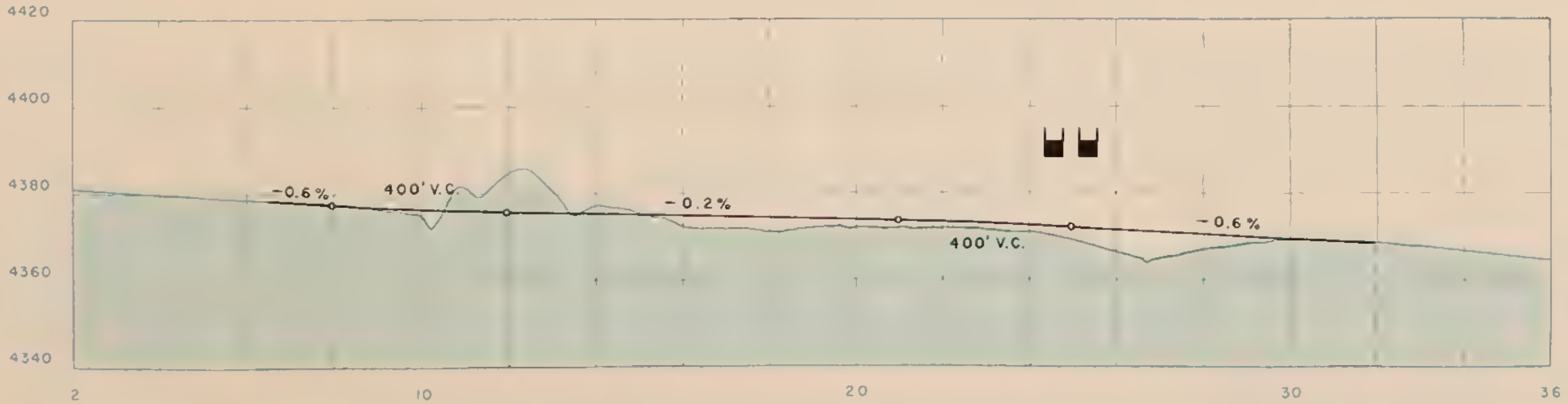
I-90 STA. 846+50



I-90 STA. 974+25



NORTHERN PACIFIC RAILROAD I-90 STA. 882+00



WHITEHALL STREET I-90 STA. 1180+00

SCALE

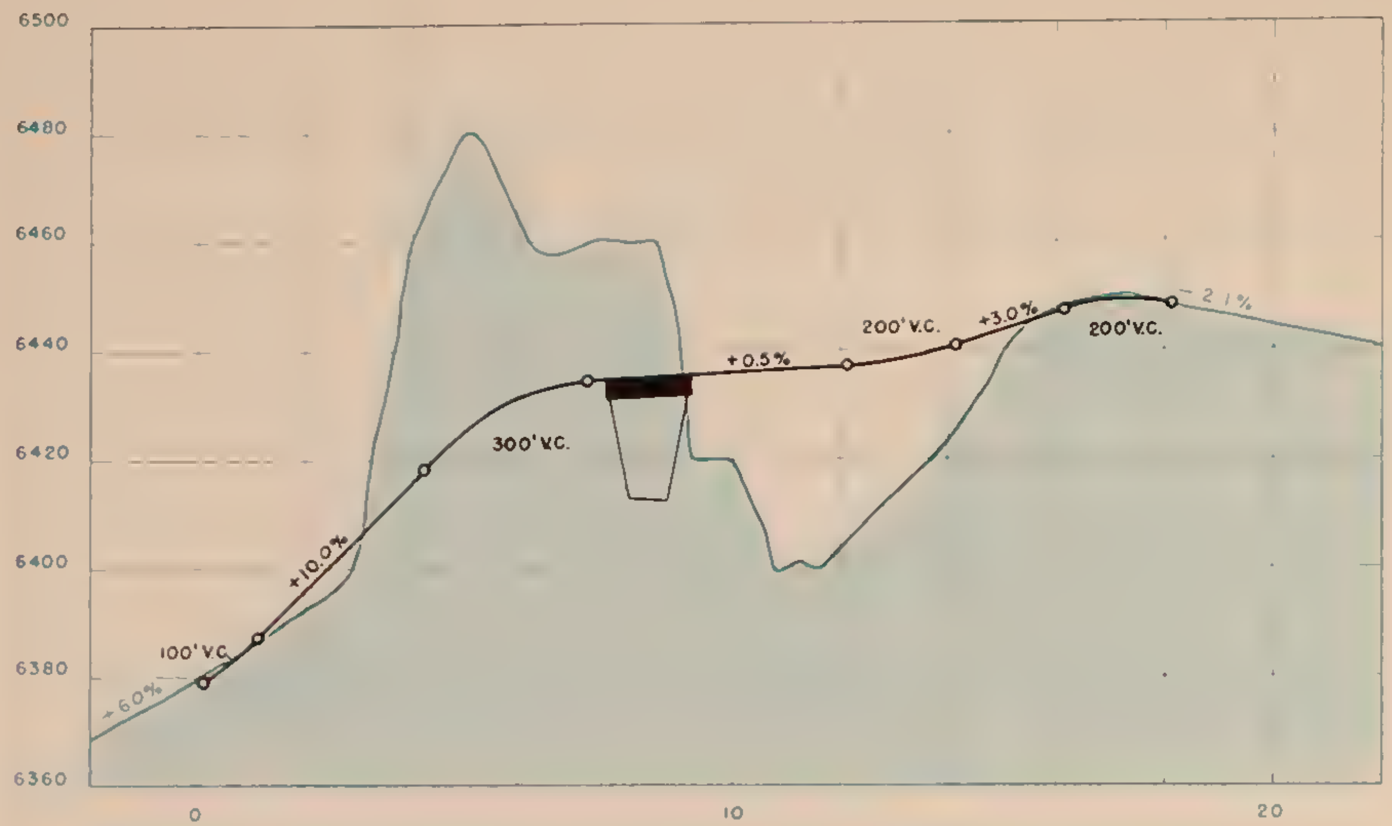
HORIZONTAL 0 100 200 400 FEET

VERTICAL 0 10 20 40 FEET

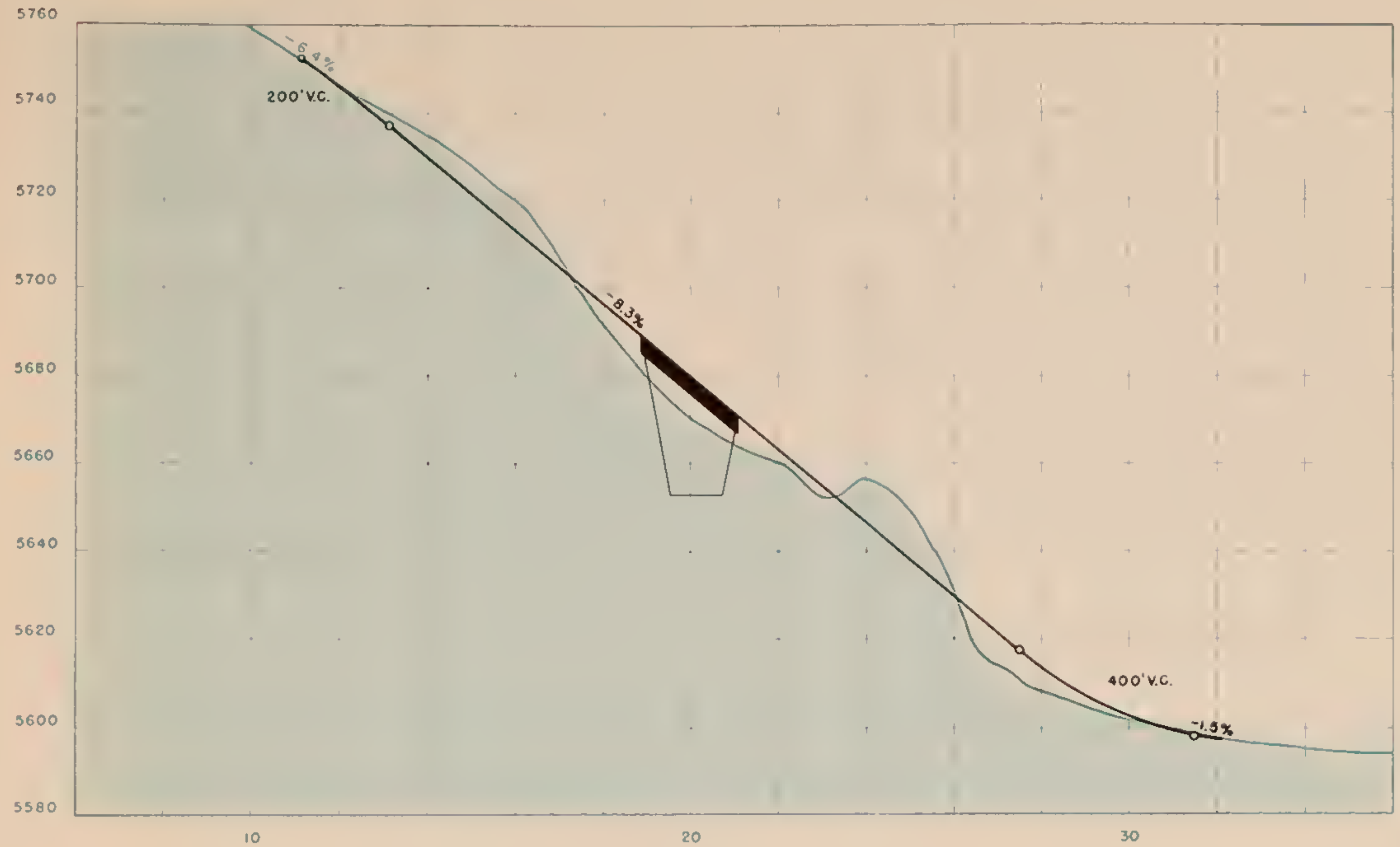
INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

PROFILES-CROSSROADS & RAILROAD LINE-1A HOMESTAKE PASS

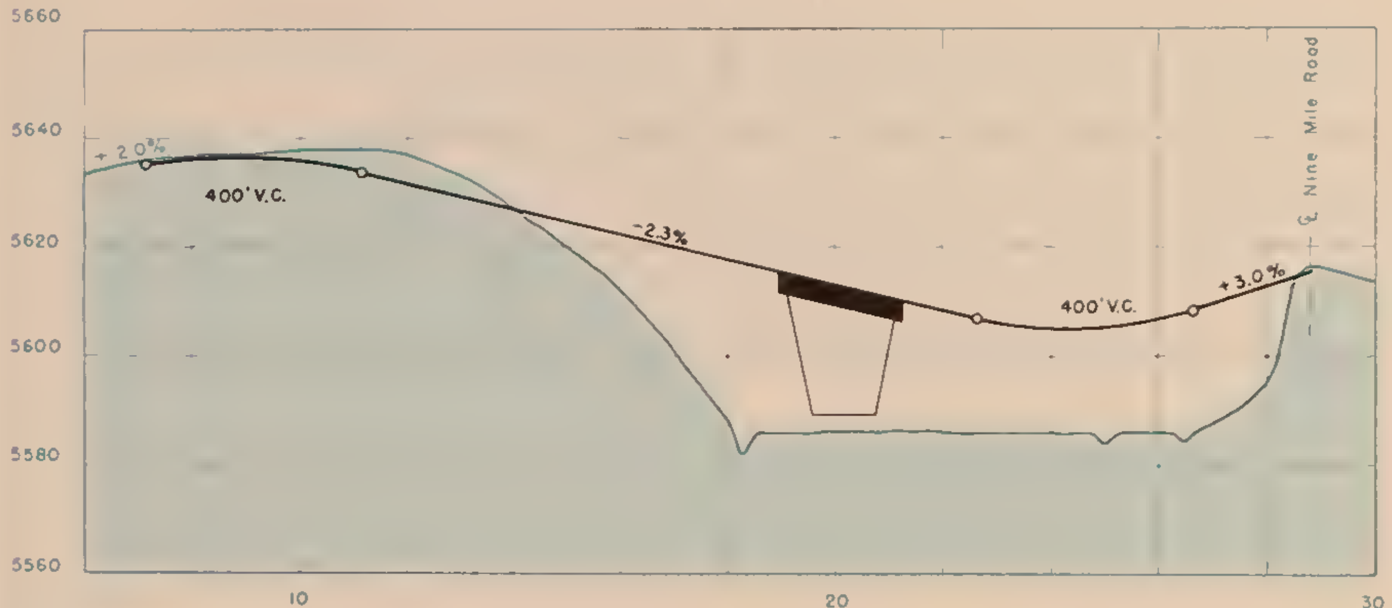
MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago



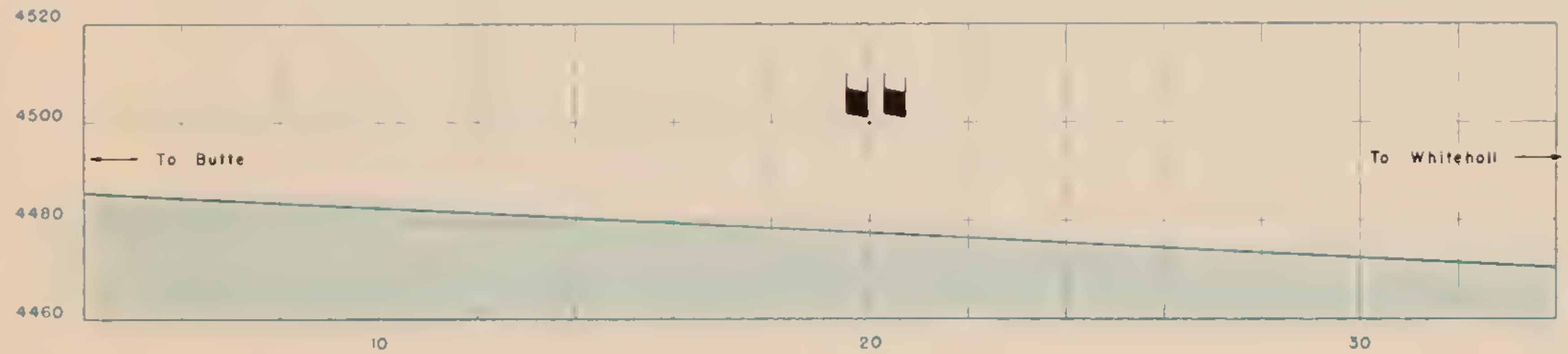
I-90 STA. 510+80



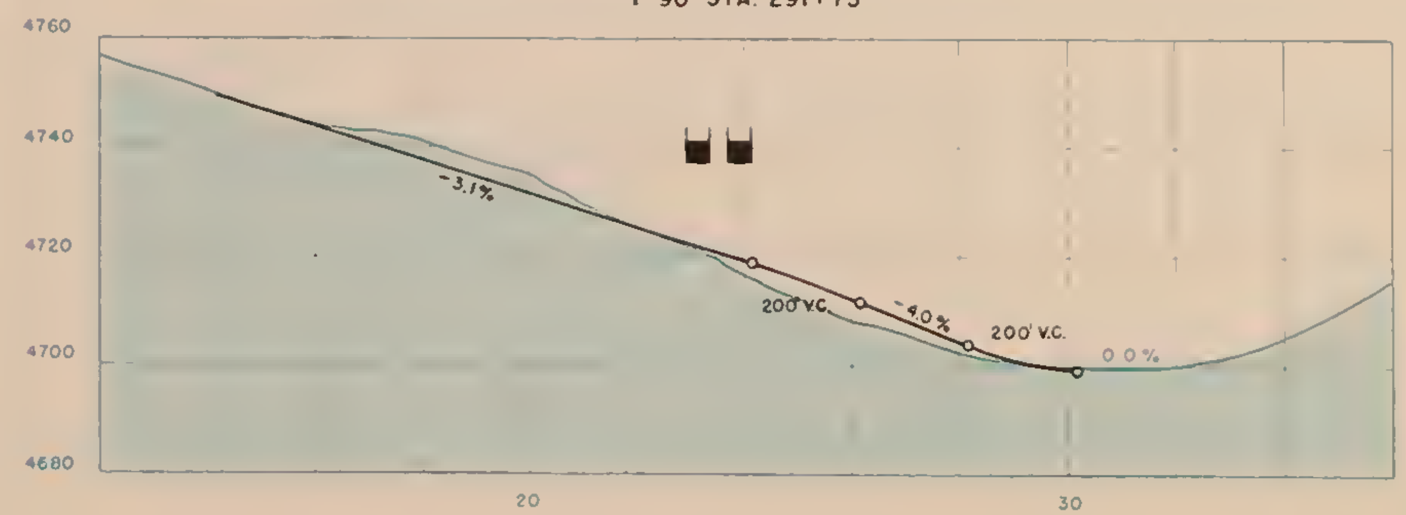
I-90 STA. 779+30



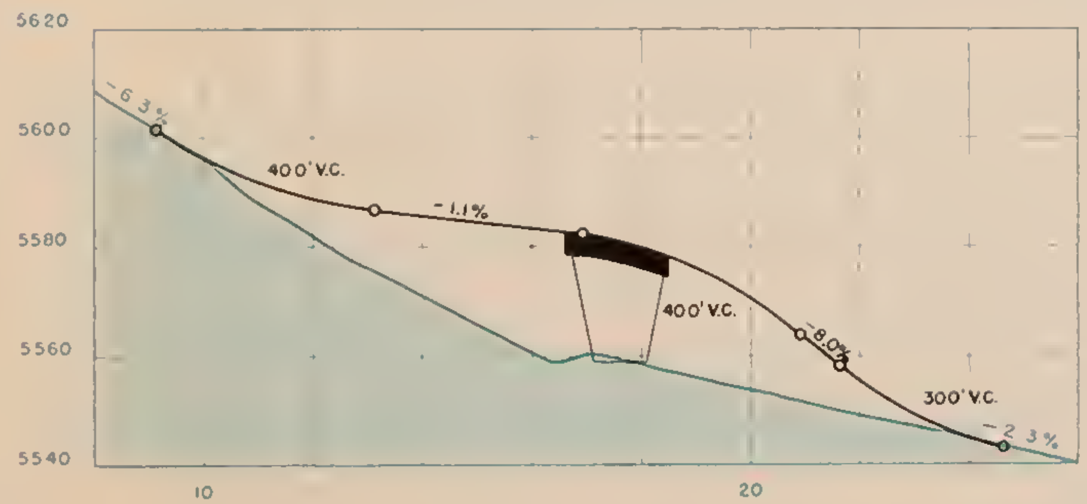
I-90 STA. 291+75



NORTHERN PACIFIC RAILROAD I-90 STA. 1250+10



MONTANA ROUTE 41 I-90 STA. 1019+10



I-90 STA. 105+70

SCALE

HORIZONTAL 0 100 200 400 FEET

VERTICAL 0 10 20 40 FEET

INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA

PROFILES - CROSSROADS & RAILROAD
LINE-2A PIPESTONE PASS

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago

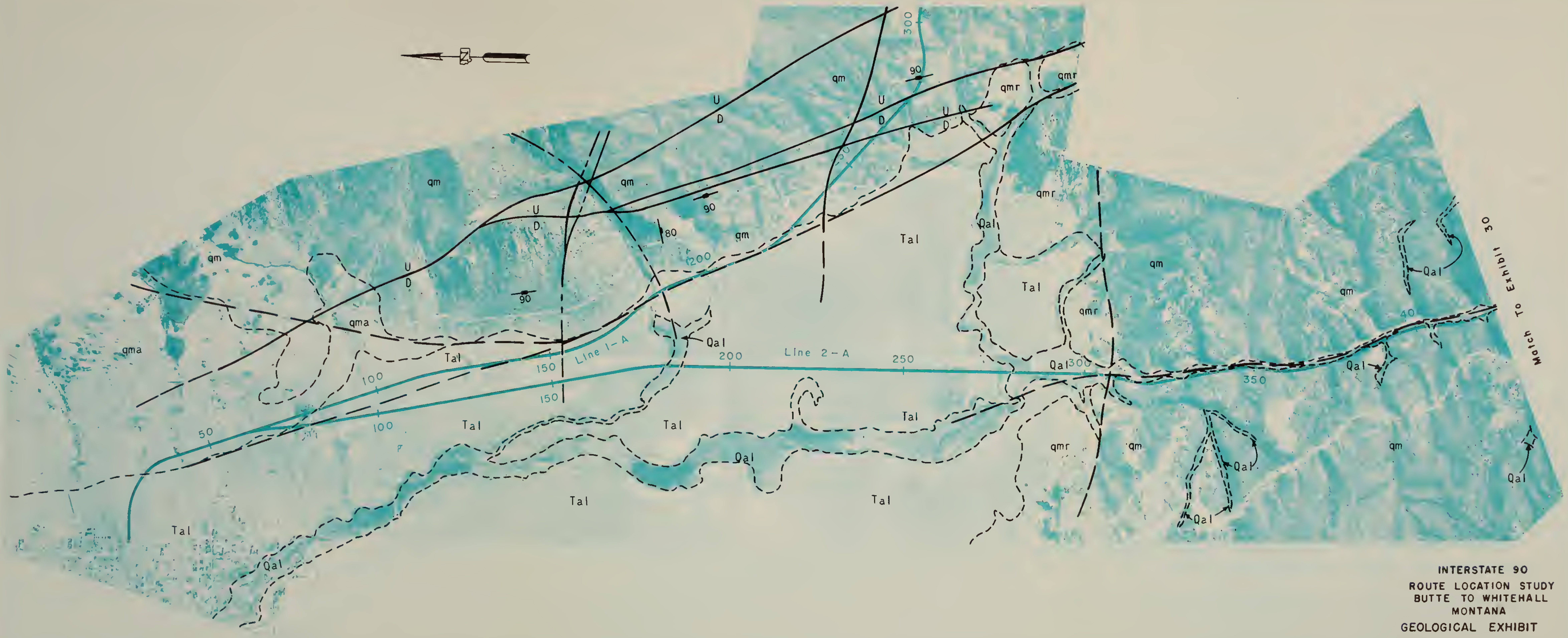
LEGEND FOR GEOLOGICAL EXHIBITS

P€	-	Metamorphosed and folded Pre-Cambrian sediments; primarily, siltstones and shales.
€	-	Metamorphosed and folded Cambrian sediments; primarily quartzites and limestones.
Kv	-	Cretaceous volcanics; basalts, gabbro, or breccia, altered by contact with Batholith.
gd	-	Granodiorite; First phase of Boulder Batholith intrusion.
qm	-	Quartz monzonite; Second phase of Boulder Batholith intrusion.
qma	-	Severely altered quartz monzonite phase - due to extreme faulting.
qmr	-	Very early stage of quartz monzonite phase, exhibiting extreme weathering and decomposition.
qm'	-	Weak quartz monzonite rock, exhibiting characteristics similar to the early stage material.
a	-	Intrusive dikes; aplitic or pegmatitic.
Tal	-	Valley fill of Tertiary and later periods; mainly sands and silts of decomposed quartz monzonite, includes boulders, slabs and talus material near the contact zone.
Ts	-	Poorly consolidated sediments of Tertiary age; primarily sands and silts with some water laid tuff and conglomerate.
Qg	-	Granular moraines and/or terraces of probable Pleistocene age; includes outwash material.
Qal	-	Recent alluvium.

	Observed	Inferred
Faults		
Fractures		
Strike and dip of dominant joint patterns	80 90	

Estimated Geologic Boundary - - - - - - - - - - - - - -

Match To Exhibit 27

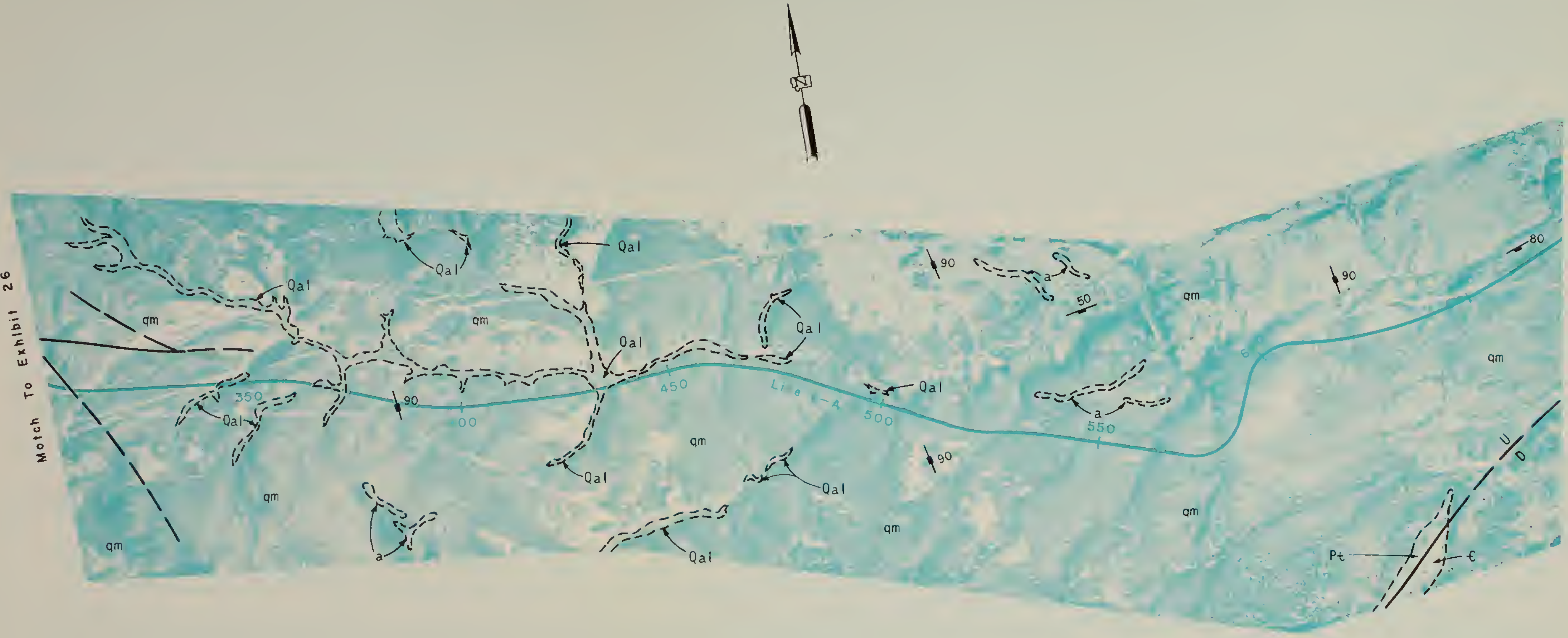


Match To Exhibit 30

2000 0 2000

INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA
GEOLOGICAL EXHIBIT

MEISSNER ENGINEERS, INC.
Consulting Engineers, Chicago



INTERSTATE 90
ROUTE LOCATION STUDY
BUTTE TO WHITEHALL
MONTANA
GEOLOGICAL EXHIBIT

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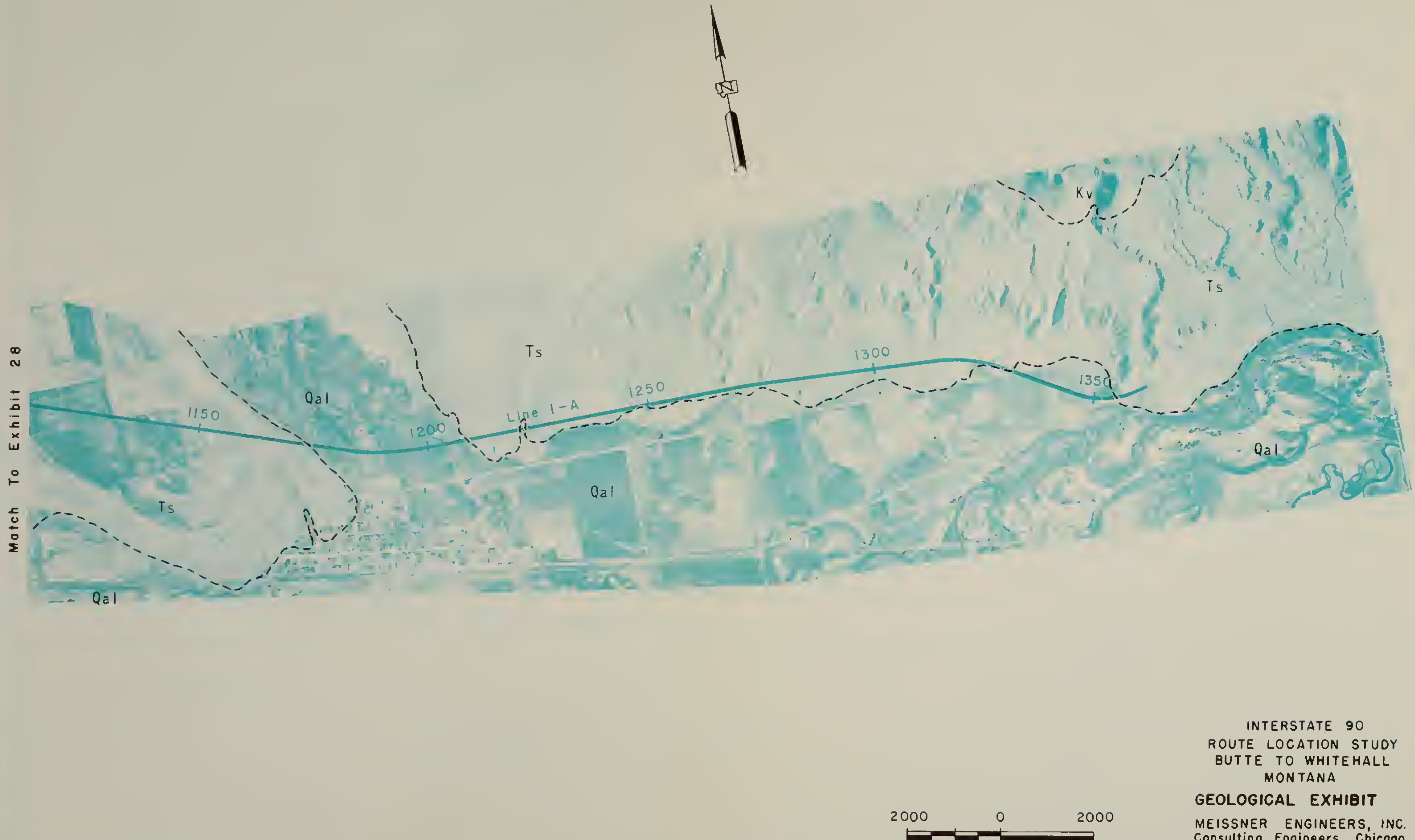

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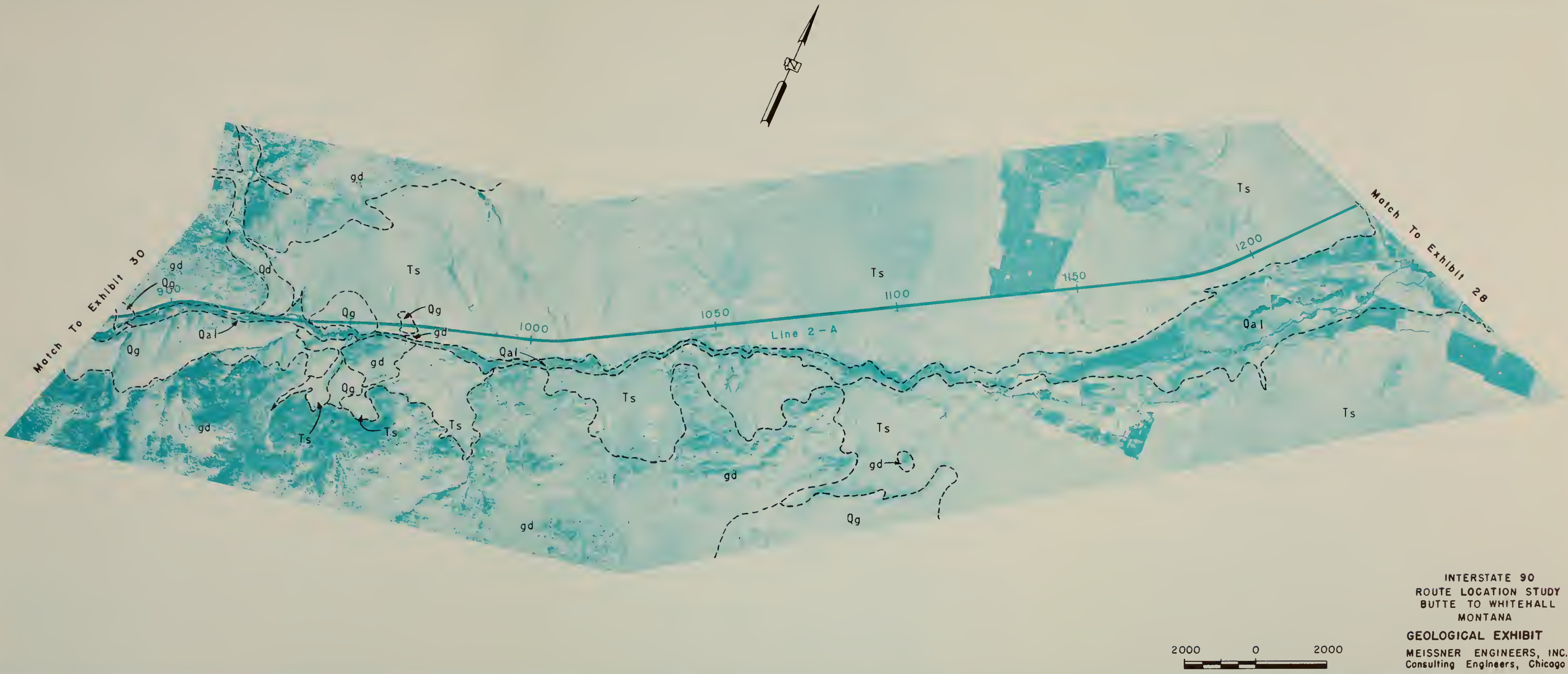

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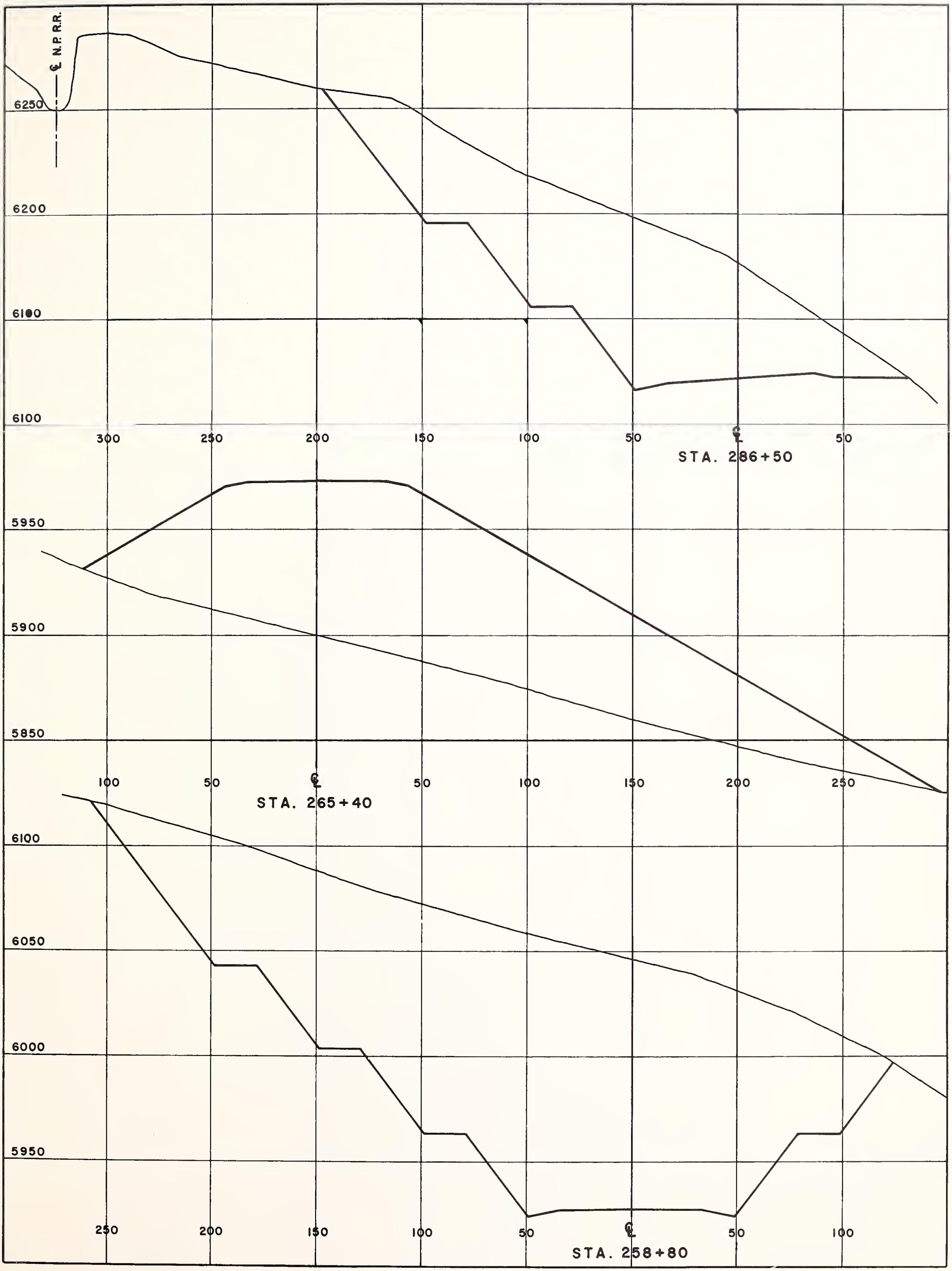
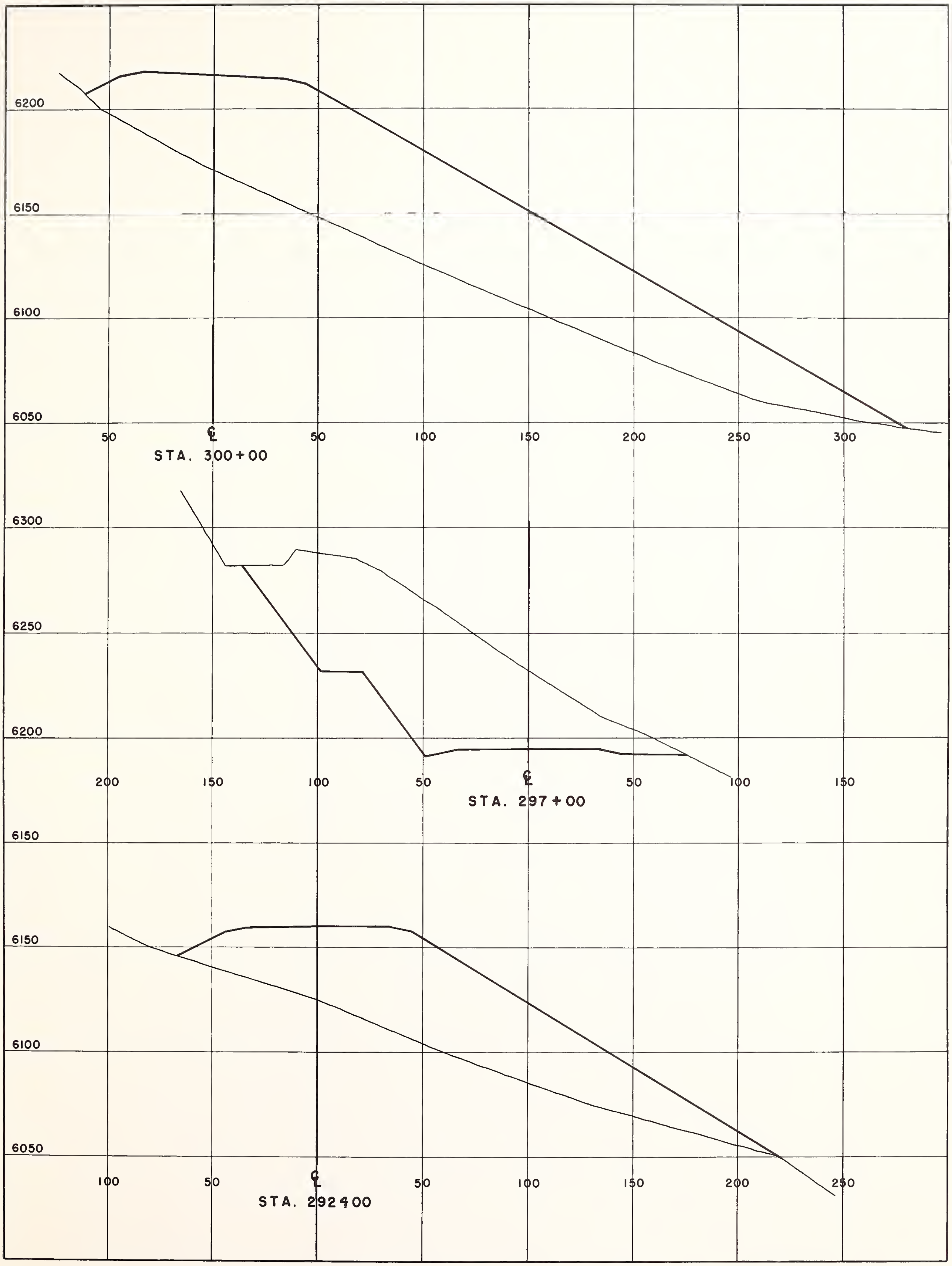


CROSS SECTIONS — HOMESTAKE PASS

SCALE : 1" = 60'



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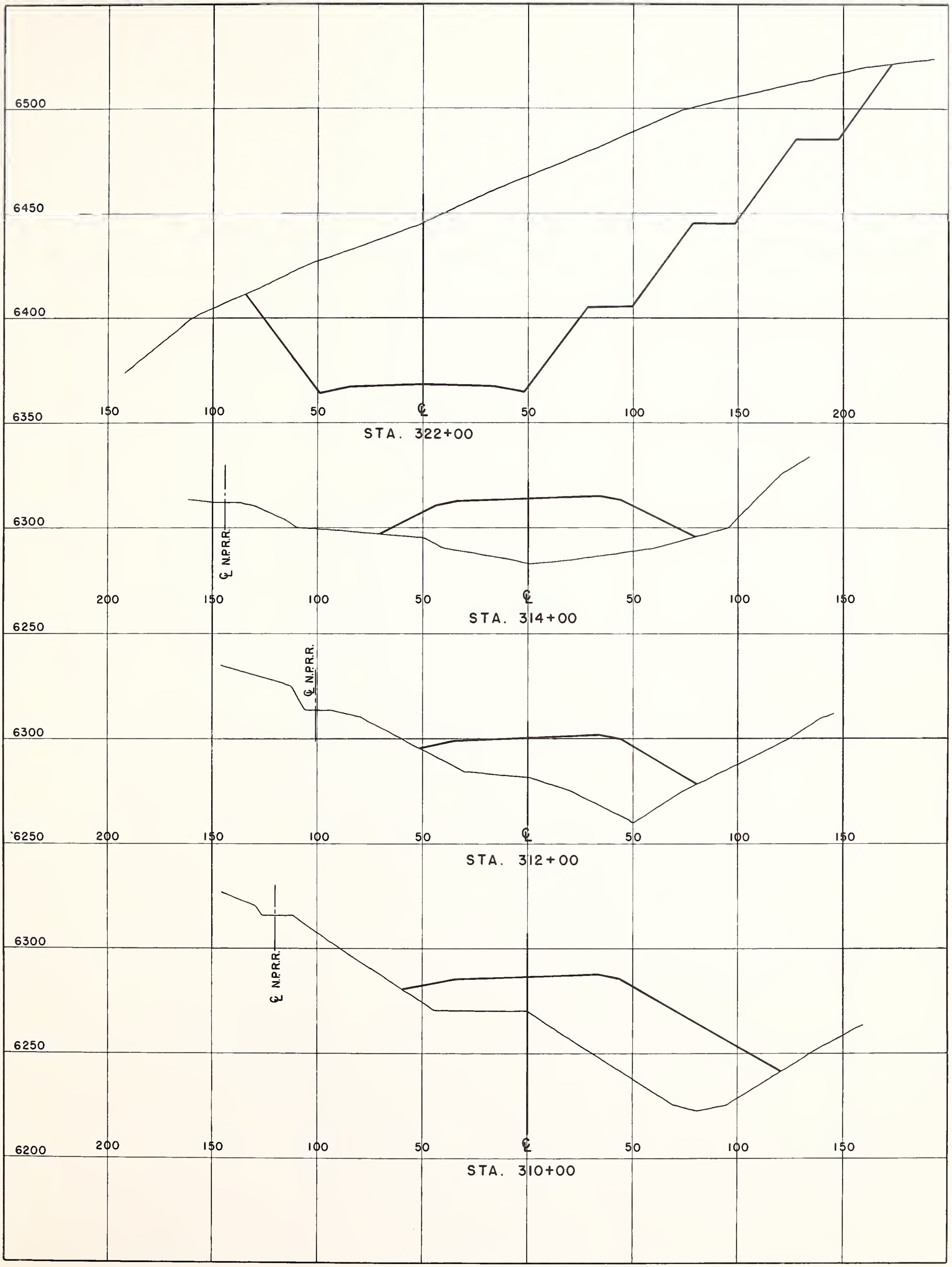

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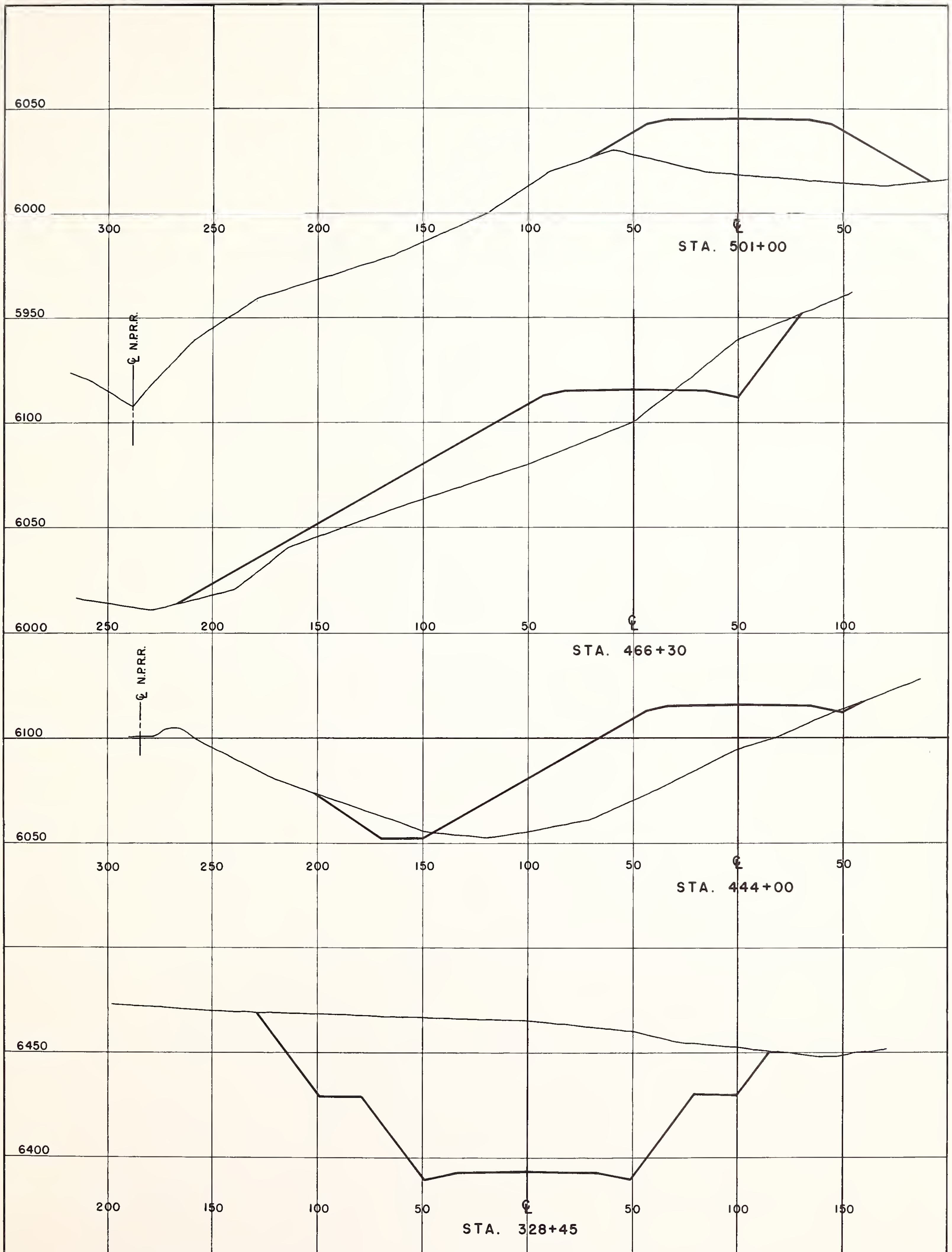

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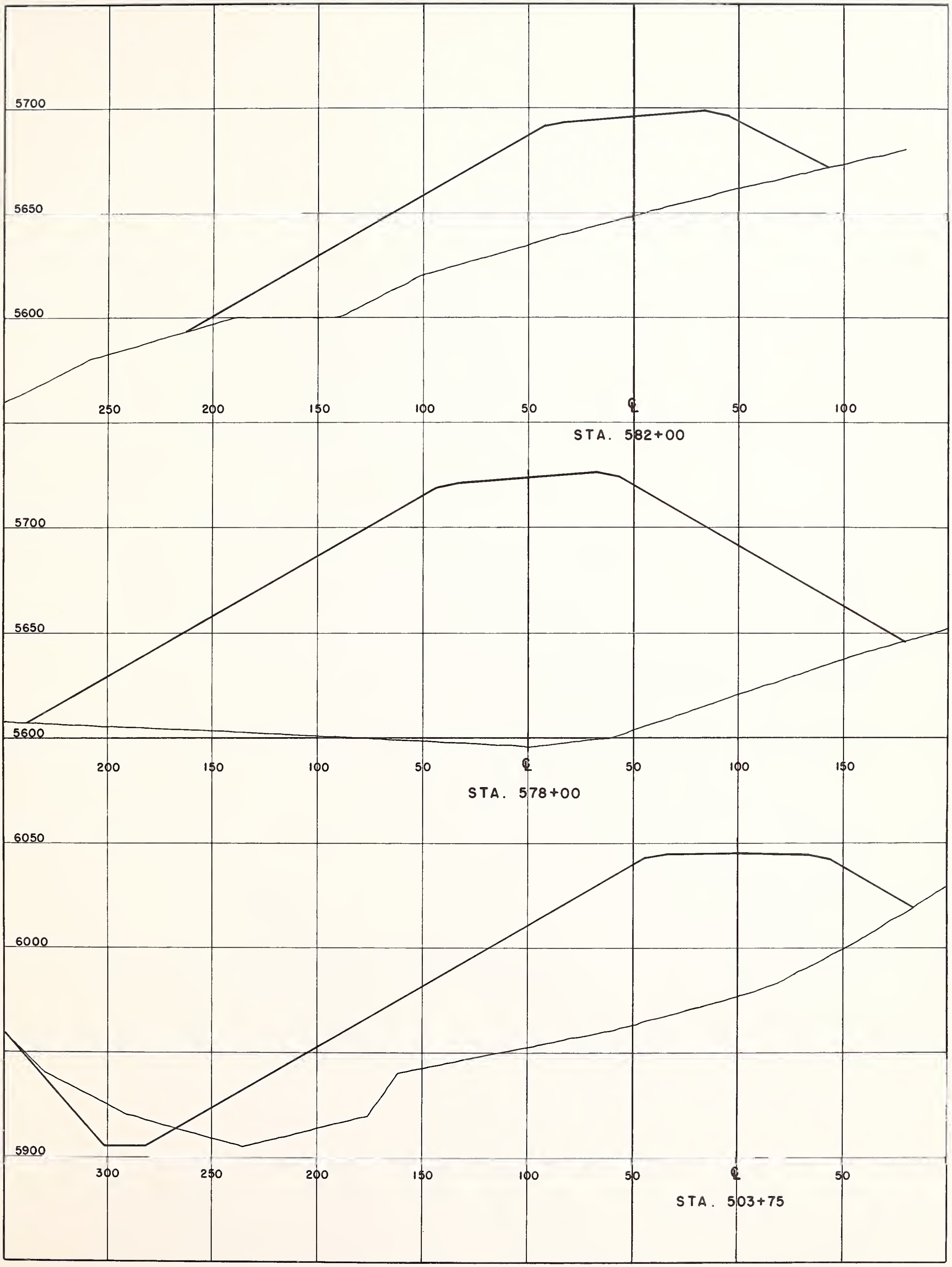

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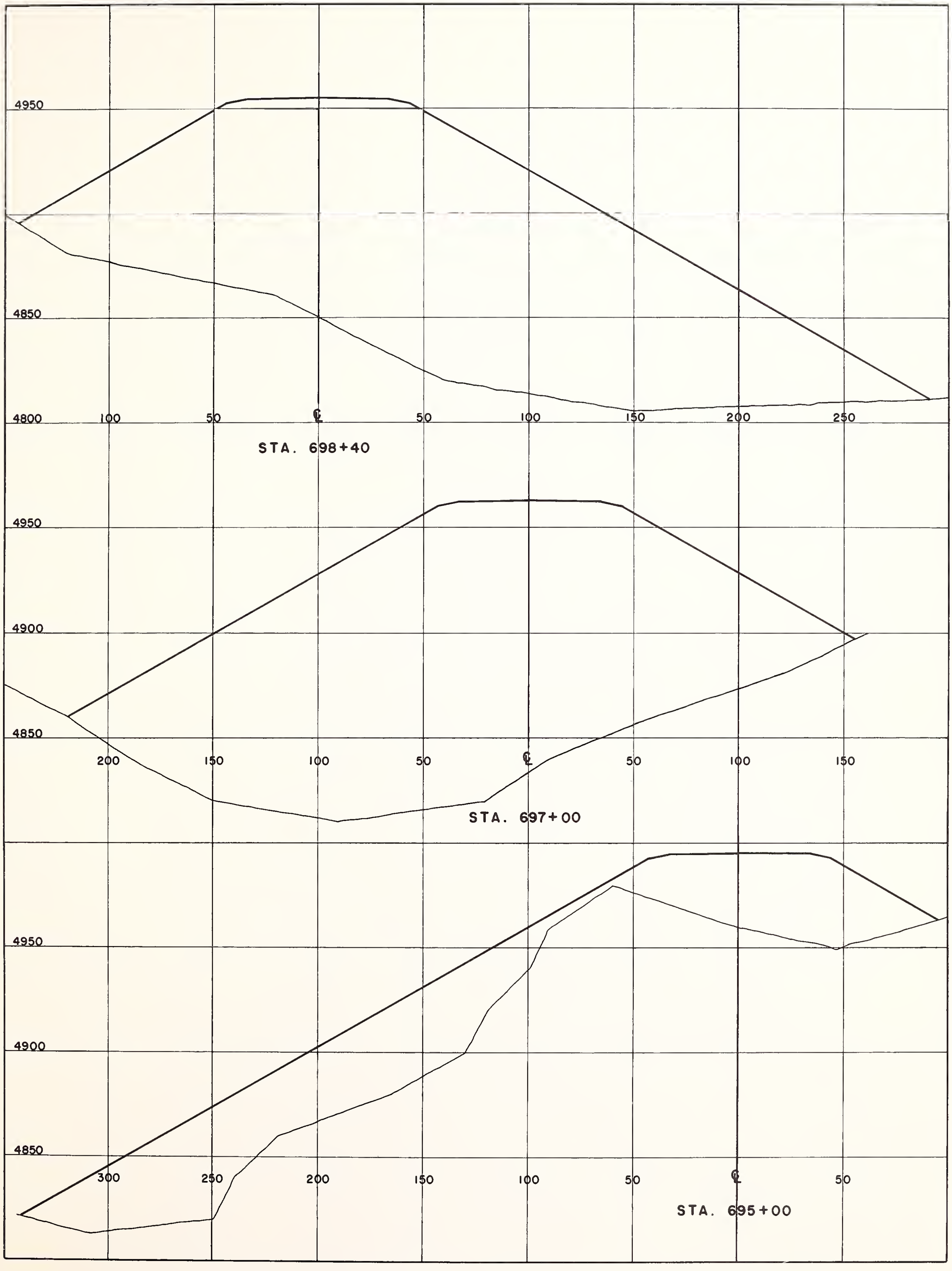

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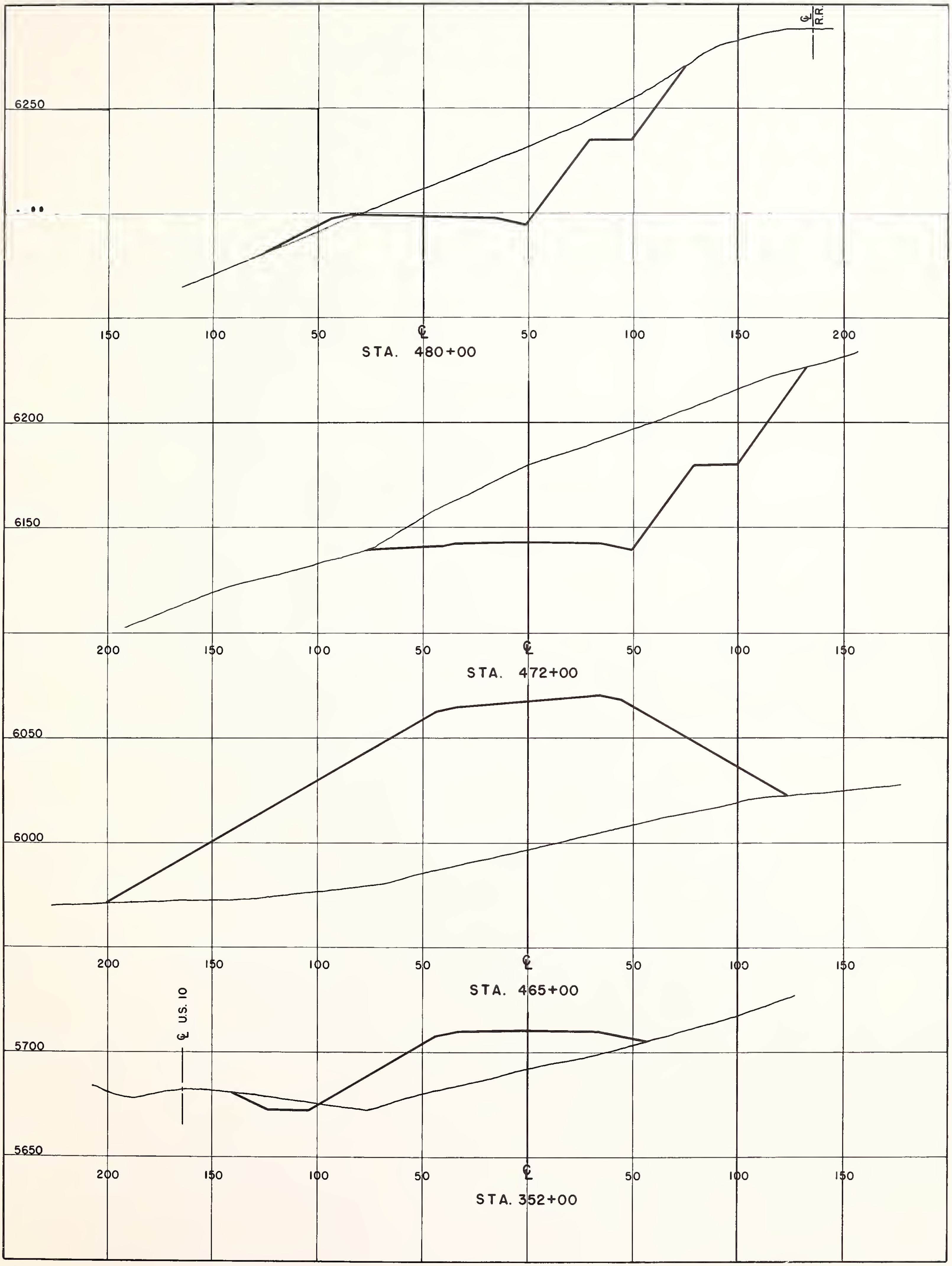

CROSS SECTIONS — PIPESTONE PASS

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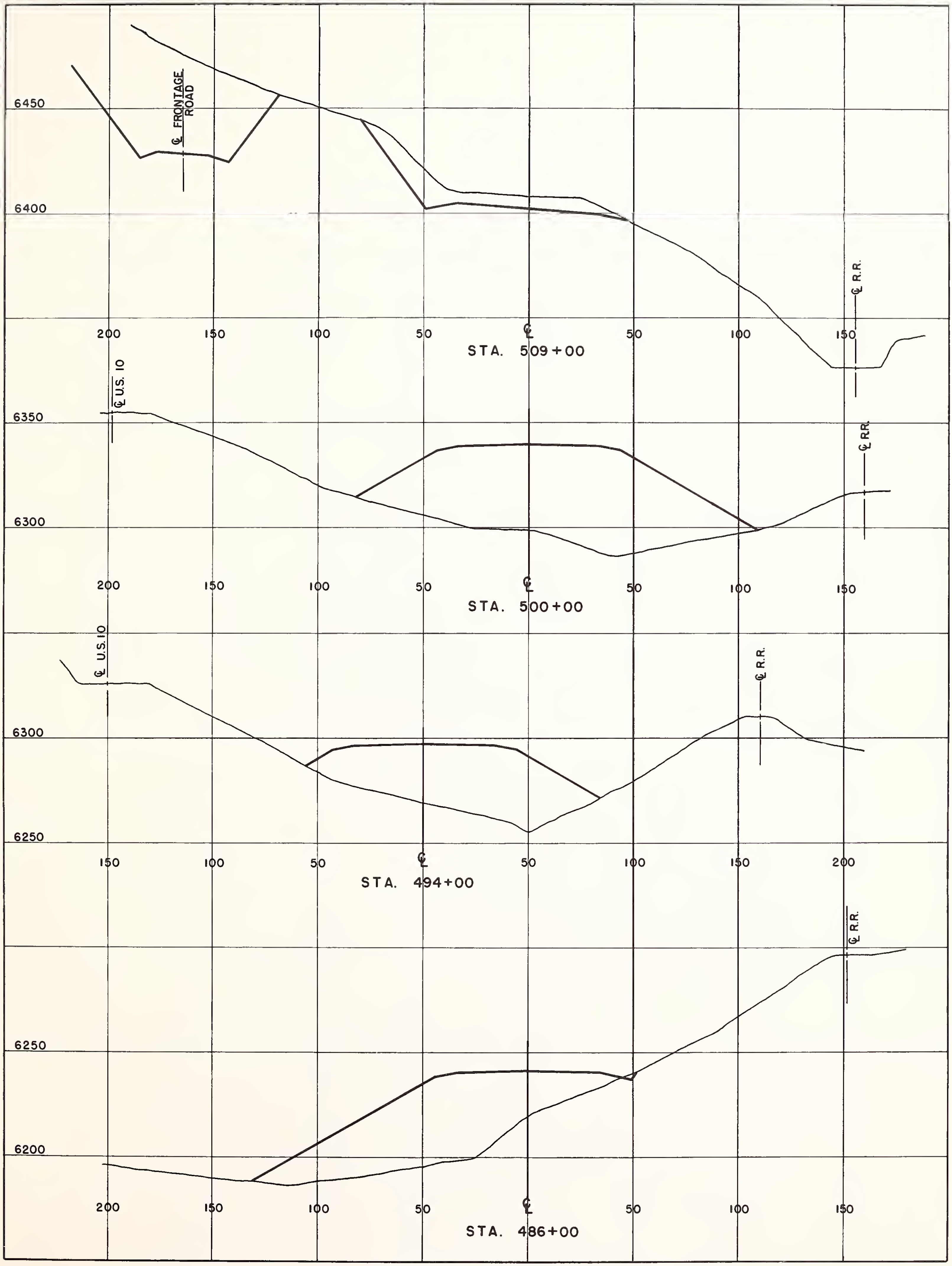

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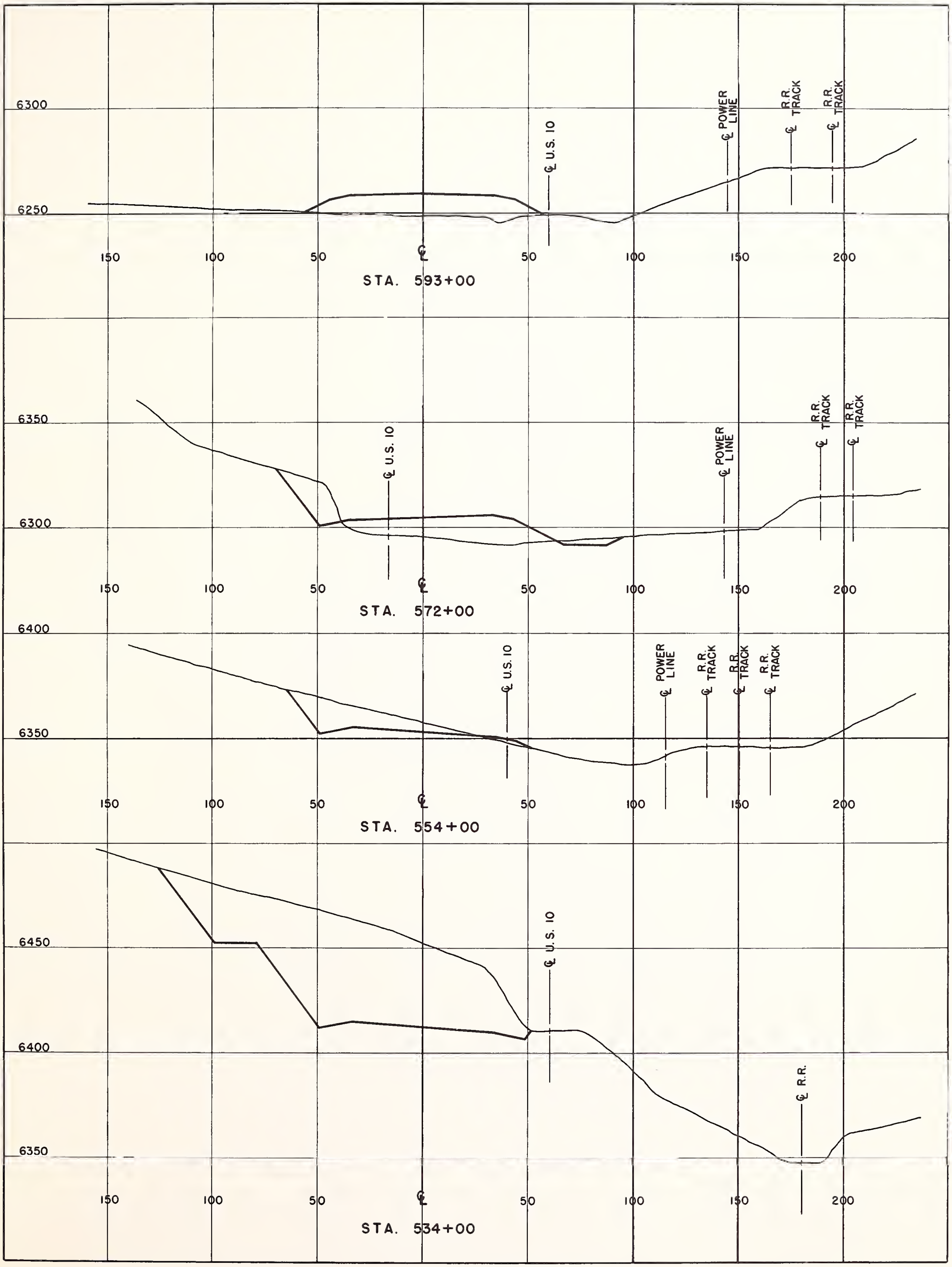

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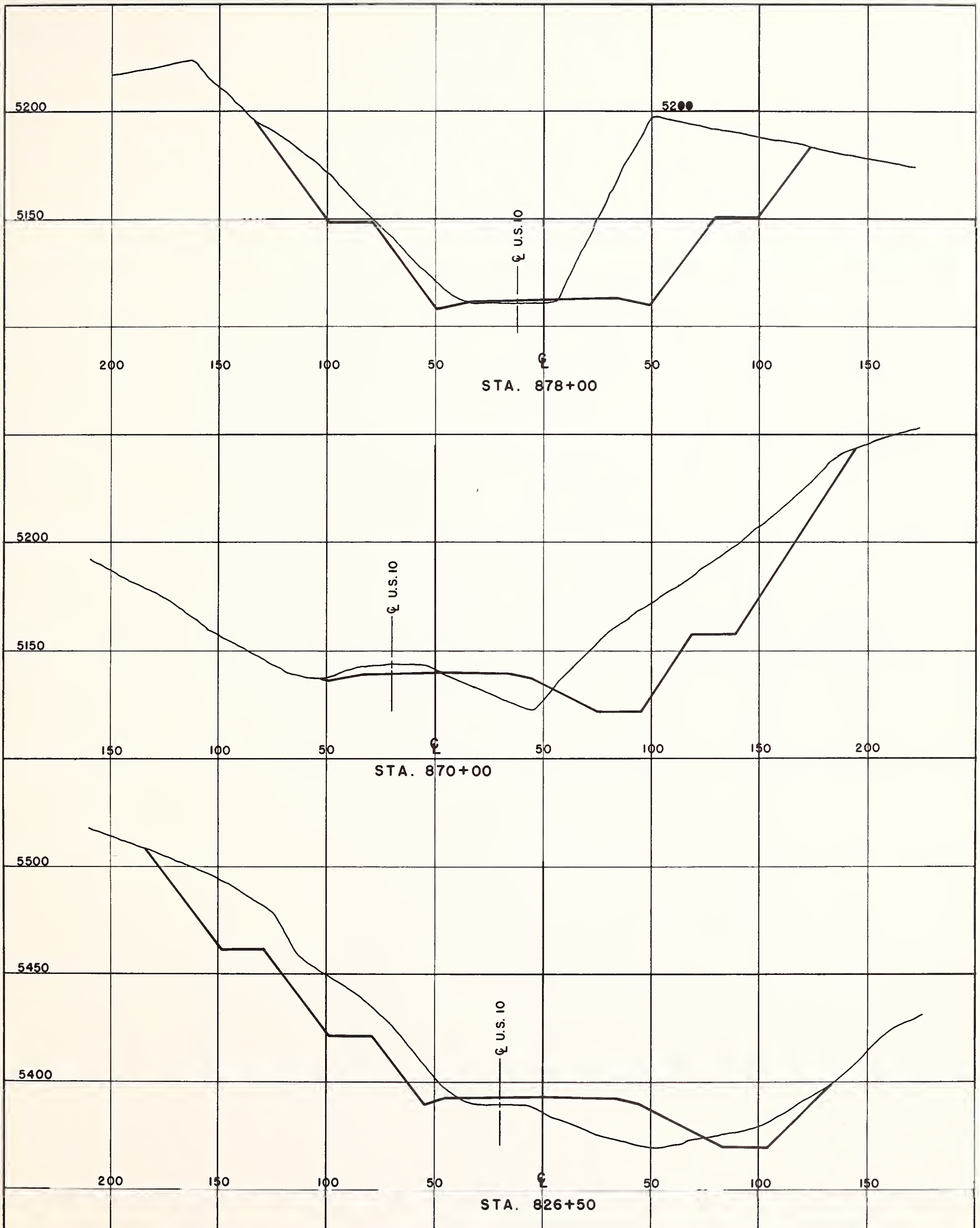

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